RETURN POSTAGE GUARANTEED
APRIL, 1960
Golf & Wolf Rds., Des Plaines, Ill.

modern castings

■ These men are patternmakers! They are shown preparing ceramic molds for revolutionary patternmaking technique involving thermal decomposition of nickel carbonyl. Details on page 47.

ALSO IN THIS ISSUE . . . ■ HOW MANY TONS of materials must be moved to make a ton of castings . . . ■ THE foundrymen's foundry . . . ■ PREVIEW of AFS Castings Congress and Exposition . . . ■ MODERNIZATION, mechanization and maintenance—3 big "M"s for profitable foundry operations . . . ■ Australian exchange paper . . . ■ 64 PAGES of top-notch advanced metalcasting technology.


Lectromelt®... for high availability
A Lectromelt furnace is regularly *in production* 96% of the time. Charging goes fast, because of the smooth-swinging, full-clearance top. Tilting is similarly rapid and safe. Sturdy construction reduces maintenance and down-time, contributing to high availability. For full information, write for Catalog 10.
McGRAW EDISON
LECTROMELT FURNACE DIVISION
McGraw-Edison Company
316 32nd Street
Pittsburgh 30, Pennsylvania
WHEN YOU MELT... Lectromelt

Circle No. 184, Page 17

modern castings

the technical magazine of the metalcasting industry

April, 1960 vol. 37, no. 4

features

TO MAKE A TON OF CASTINGS by Jack H. Schaum **24**
Here's a question that has gone unanswered a long time. Now we have the answer.

THE FOUNDRYMEN'S FOUNDRY by Walter R. Colsmann **30**
If your foundry needs cast-to-size patterns, core boxes, molds or dies, then look to a specialist for help.

HERE'S HOW . . . Castings are being used . . . problems are being solved **33**

MODERNIZATION . . . MECHANIZATION . . . MAINTENANCE by Vernon E. Lich **36**
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Preview of metalcasting technology scheduled for the 1960 AFS Congress.

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Exhibitors' products are now being previewed in MODERN CASTINGS.

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A compendium of technology to brief foundrymen on the fundamentals of metal solidification.

SOLIDIFICATION OF CAST STEEL by C. W. Briggs **157**
These solidification principles are an essential foundation for proper gating and risering of steel castings.

SOLIDIFICATION OF CAST IRON by C. K. Donoho **169**
Important differences exist in the solidification mannerisms of white iron, gray iron and ductile iron.

CASTING LOSS REDUCTION PROGRAM by H. W. Dietert **172**
Twelve sources of casting losses attributable to sand are identified, causes listed and corrective action spelled out.

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HOW DO YOU KNOW IT IS DUCTILE? by G. F. Thomas **182**
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FLUIDITY OF 85-5-5-5 AND COMPOSITION M METAL by R. A. Rosenberg, H. D. Brody and F. C. Monkman, Jr. **185**
Metal fluidity can be markedly increased by coating molds with hexachloroethane, $SnCl_2$ or lamp black.

PATTERN AND CORE BOX EQUIPMENT FOR BLOWING FOUNDRY SANDS, venting and design by Z. Madacey **193**
Use these tips in core-box design and venting to achieve maximum strength cores.

CANADIAN NON-FERROUS AND IRON FOUNDRY SAND PRACTICE SURVEY, REPORT OF AFS SAND DIV. CANADIAN COMMITTEE 8-Y by A. E. Murton **199**
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EDUCATE ENGINEERS THAT CASTINGS CAN SOLVE DESIGN PROBLEMS **161**

modern castings

Golf and Wolf Rds., Des Plaines, Ill.
VAnderbilt 4-0181

Published by
American Foundrymen's Society

GENERAL MANAGER
WM. W. MALONEY

news of the industry

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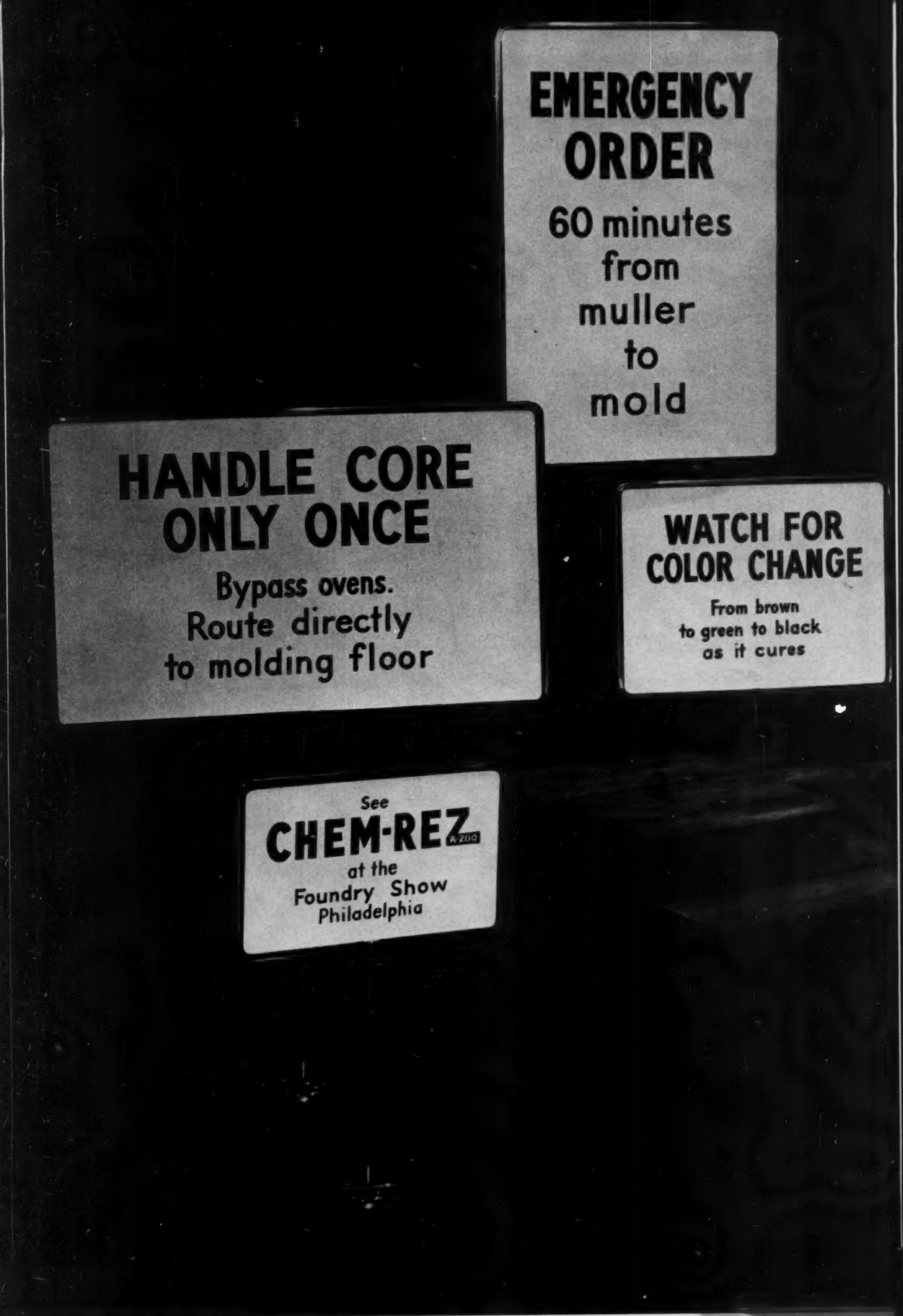
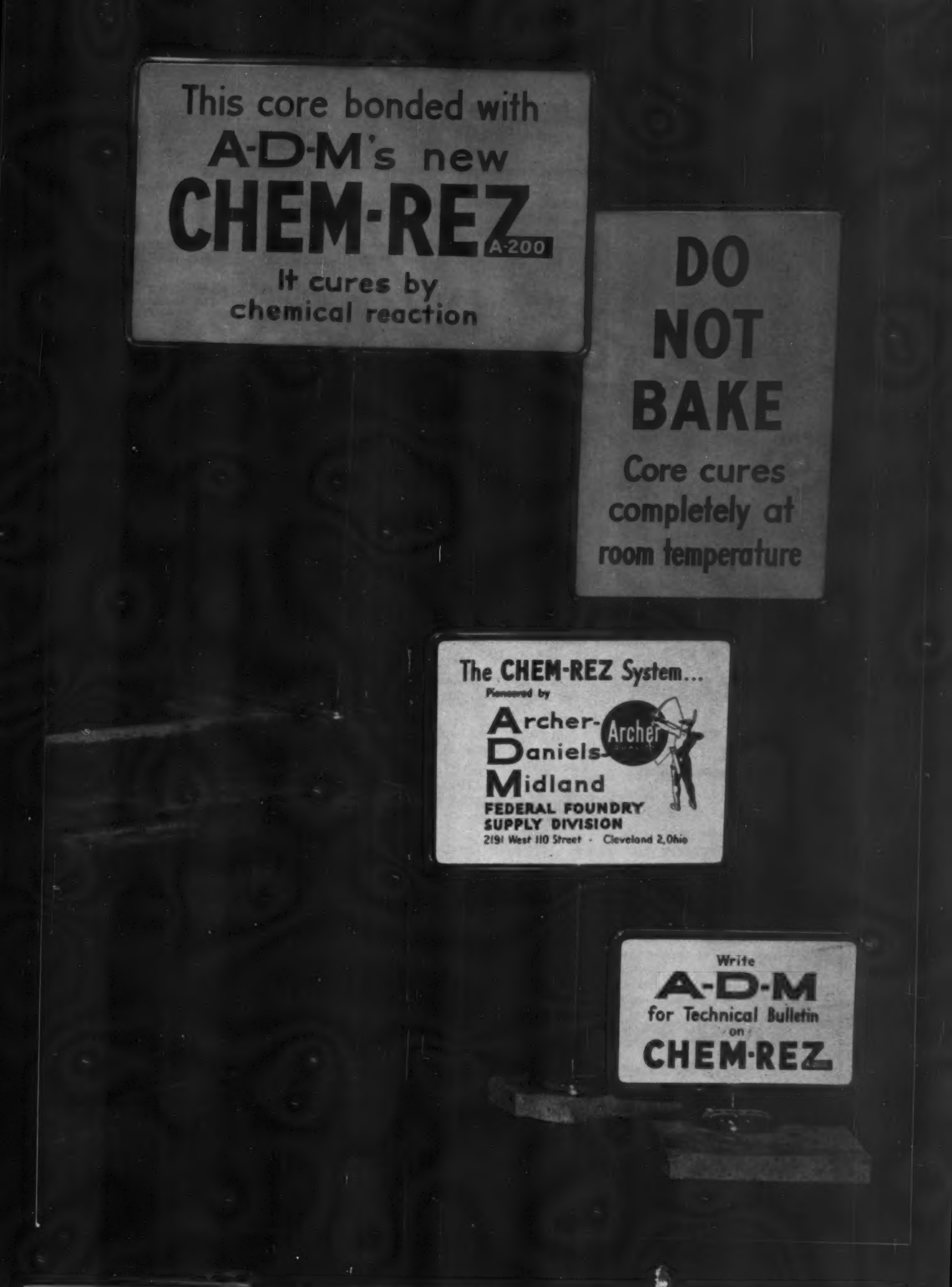

EMERGENCY ORDER
60 minutes from muller to mold
HANDLE CORE ONLY ONCE
Bypass ovens. Route directly to molding floor
WATCH FOR COLOR CHANGE
From brown to green to black as it cures
See
CHEM-REZ
at the Foundry Show Philadelphia



This core bonded with
A-D-M's new
CHEM-REZ
A-200
It cures by
chemical reaction
DO
NOT
BAKE
Core cures
completely at
room temperature
The CHEM-REZ System...
Archer-
Daniels-
Midland
Archer
FEDERAL FOUNDRY
SUPPLY DIVISION
2191 West 110 Street · Cleveland 2, Ohio
Write
A-D-M
for Technical Bulletin
on
CHEM-REZ

future meetings and exhibits

April 4-6 . . American Institute of Mining, Metallurgical & Petroleum Engineers, National Open Hearth Steel Conference and Blast Furnace, Coke Oven and Raw Materials Conference. Palmer House, Chicago.

April 4, Chicago . . **April 7,** Milwaukee . . **April 12,** Newark, N. J. . . **April 14,** Toronto, Canada . . **April 18,** Cleveland . . **April 21,** Cincinnati . . **Gray Iron Founders' Society,** Castings Clinics.

April 7-8 . . American Zinc Institute, Annual Meeting. Chase-Park Plaza Hotel, St. Louis.

April 13-14 . . Malleable Founders Society, Market Development Conference. Edgewater Beach Hotel, Chicago.

April 21-28 . . American Society of Tool & Manufacturing Engineers, Annual Meeting & Tool Show. Artillery Armory and Sheraton-Cadillac Hotel, Detroit.

April 24-28 . . American Ceramic Society, Annual Meeting. Bellevue-Stratford Hotel, Philadelphia.

April 25-26 . . American Society of Mechanical Engineers, Maintenance & Plant Engineering Conference. Chase-Park Plaza, St. Louis.

April 25-29 . . American Welding Society, Annual Convention. Biltmore Hotel, Los Angeles.

April 26-29 . . National Industrial Sand Association, Annual Meeting. Key Biscayne, Fla.

April 27 . . American Industrial Hygiene Association, Industrial Health Conference. War Memorial Bldg., Rochester, N. Y.

April 29 . . Malleable Founders Society, Western Section Meeting. Drake Hotel, Chicago.

May 3-5 . . Iron and Steel Institute, Annual Meeting. London, England.

May 9-13 . . AFS 64th Annual Castings Congress & Exposition. Convention Hall, Philadelphia.

May 9 . . Investment Casting Institute, Design Clinic. Essex House, Newark, N. J.

May 12 . . National Castings Council, Annual Meeting. Warwick Hotel, Philadelphia.

May 22-26 . . Air Pollution Control Association, Annual Meeting. Netherland-Hilton Hotel, Cincinnati.

May 23-31 . . Magnesium Association, Annual Meeting. London and Manchester, England and Hannover, Germany.

May 25-26 . . American Iron and Steel Institute, General Meeting. Waldorf-Astoria Hotel, New York.

June 6-8 . . Malleable Founders Society, Annual Meeting. Elbow Beach Surf Club, Hamilton, Bermuda.

June 16-17 . . AFS Chapter Officers Conference. AFS Headquarters, Des Plaines, Ill. and LaSalle Hotel, Chicago.

June 19-21 . . Alloy Casting Institute, Annual Meeting. The Homestead, Hot Springs, Va.

June 26-July 1 . . American Society for Testing Materials, Annual Meeting & Exhibit. Chalfonte-Haddon Hall, Atlantic City, N. J.

Sept. 14-15 . . American Die Casting Institute, Annual Meeting. Edgewater Beach Hotel, Chicago.

Sept. 19-24 . . International Foundry Congress. Zurich, Switzerland.

Sept. 22-23 . . National Foundry Association, Annual Meeting. Edgewater Beach Hotel, Chicago.

Sept. 27 . . American Management Association, Annual Meeting. Hotel Astor, New York.

Sept. 27-30 . . Association of Iron and Steel Engineers, Annual Convention & Exposition. Public Auditorium, Cleveland.

Oct. 12 . . Cast Bronze Bearing Institute, Annual Meeting. Grove Park Inn, Asheville, N. C.

Oct. 12-14 . . Gray Iron Founders' Society, Annual Meeting. Netherland-Hilton Hotel, Cincinnati.

Oct. 13-15 . . Non-Ferrous Founders' Society, Annual Meeting. Grove Park Inn, Asheville, N.C.

Oct. 17-18 . . Magnesium Association, Annual Convention. Pick Carter Hotel, Cleveland.

Continued on page 8

Modern Castings is indexed by Engineering Index, Inc., 29 West 39th St., New York 18, N. Y. and microfilmed by University Microfilms, 313 N. First St., Ann Arbor, Mich.
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AUDITED PAID CIRCULATION ABC

Circle No. 150, Page 17

future meetings

Continued from page 6

Oct. 17-21 . . American Society for Metals, Annual Meeting and Metal Exposition & Congress. Trade & Convention Center, Philadelphia.

Oct. 17-21 . . National Safety Council, National Safety Congress. Chicago.

Oct. 19-21 . . National Management Association, Annual Meeting. Dinkler Hotel, Atlanta, Ga.

Oct. 20-22 . . Foundry Equipment Manufacturers Association, Annual Meeting. The Greenbrier, White Sulphur Springs, W. Va.

Nov. 27-Dec. 2 . . American Society of Mechanical Engineers, Annual Meeting. Statler Hotel, New York.

Nov. 14-16 . . Steel Founders' Society of America, Technical & Operating Conference. Carter Hotel, Cleveland.

Dec. 6-8 . . National Association of Manufacturers, Annual Meeting. Waldorf-Astoria Hotel, New York.

Dec. 12-14 . . Material Handling Institute, Annual Meeting. Savoy-Hilton Hotel, New York.

1961

March 13-14 . . Steel Founders' Society of America, Annual Meeting. Drake Hotel, Chicago.

AFS Chapter meetings for April appear on page 129.

product report . . .

Use of corrugated shipping containers stapled to expendable wooden pallets is saving handling time on gray and malleable castings at Dalton Foundries, Inc., Warsaw, Ind.

Cartons are filled with loose castings in the finishing, grinding and cleaning department, then taken to storage areas and placed on metal racks. After the order is completed, the cartons are speedily loaded onto commercial carriers by fork-lift trucks.

Formerly, castings were put in barrels or heavy wooden boxes and dumped into loose piles on the floor. In filling orders, castings were put in burlap bags or containers and wheeled to trucks by various hand methods.

Two sizes of boxes, manufactured by Mead Containers, Div. Mead Corp., capable of carrying 1000-3000 lb of castings, are used by Dalton.

For More Information, Circle No. 40, Page 17

Circle No. 152, Page 17

before Marco Polo went east and brought back a load of spices. Sure must have been flat.) Back on the subject of sand — the benefits of more ingredients, such as Black Hills and Dixie, began to pile up. Lower moisture, better toughness, better finish, more control, closer tolerances, etc. With a full line of bond clay under its belt, ECP next introduced the Age of Additives.

Further developments came fast. High-Pressure Molding, PLASTI-BOND, TRIPLACT and Z-FLO filled out the framework. Today these products are hard-working tools that help the foundryman produce castings that measure up to the tighter, harder-to-meet specifications he gets from his customers. When you get right down to it, Eastern Clay Products is helping the foundryman's sales force as much as the men in the shop.

But let's get down to the additives themselves. Why so many? Wouldn't one additive improve overall sand quality and justify its existence? Sure, but let's go back to the art of cooking for a minute. To brighten the flavor, our cook adds sugar for sweetness, vinegar for a sour "bite," and Accent® to make the flavor sing. She depends heavily on additives to achieve the desired

MAPLEX

Pure hard maple flour that provides 100% increase in hot strength at 2000 F and highest amount of reducing or cleaning action gas.

end result — and thank heaven she doesn't use the same additive for everything!

TRIPLACT, for instance, has a triple action. (1) It increases flowability,

TRIPLACT

Additive to core and molding sand; reduces scabbing, stops veins and fins in cores, improves finish, imparts higher flowability.

makes molds and cores harder, denser. (2) It provides a strong reducing atmosphere that helps stop burn-in and penetration. (3) It controls both expansion and collapsibility without causing lumpy shakeout or pitch balls.

PLASTI-BOND, on the other hand, retains flowability, permits lower moisture content, and increases sand toughness and strength at the same time. Sound amazing? Well it is; PLASTI-BOND is an amazing additive. It was developed to meet

PLASTI-BOND

The only way to combine toughness, flowability, strength and low moisture in a fine sand. Developed for high-pressure molding, but has wide application.

the demands of high-pressure molding and to produce "precision" castings in green sand. But PLASTI-BOND is not confined to high-pressure molding alone. The same properties find applications in every casting operation requiring improved finish, better weight control, extended versatility, fast, economical cleaning and absence of casting defects.

MAPLEX is a pure, unadulterated hard sugar maple wood flour. It works well with PLASTI-BOND — better than any other wood flour we

Z-FLO

Newest of the additives. Highly durable; reduces cuts and washes, deep pockets, broken molds. Offers high dry strength and toughness, with maximum flowability.

know — in arriving at just the right balance of molding properties for a given job. A good muller man can take these two additives and "feel" his way — just like a good cook — and give you a sand as tough and gummy, or as smooth and soft, as you want it. To increase toughness, increase the PLASTI-BOND. If it's too tough, add MAPLEX. Increase the MAPLEX to improve shakeout and flowability.

Z-FLO, in addition to toughness, offers good dry strength. In fact, it is often substituted for pitch — but with improved flowability. It's the latest addition to ECP's full line of additives . . . qualifies as a member of the family because of its durable, easy-to-mull properties.

Add it all up. Additives can give foundry sand more versatile properties than most people realize. There's a right additive for what you do. And we have a wide enough range of products *and* know-how to make our recommendations both impartial and accurate. We can select a product to fit your job, rather than look for a job to fit the product.

IMC Products for Growth*

*Trademark

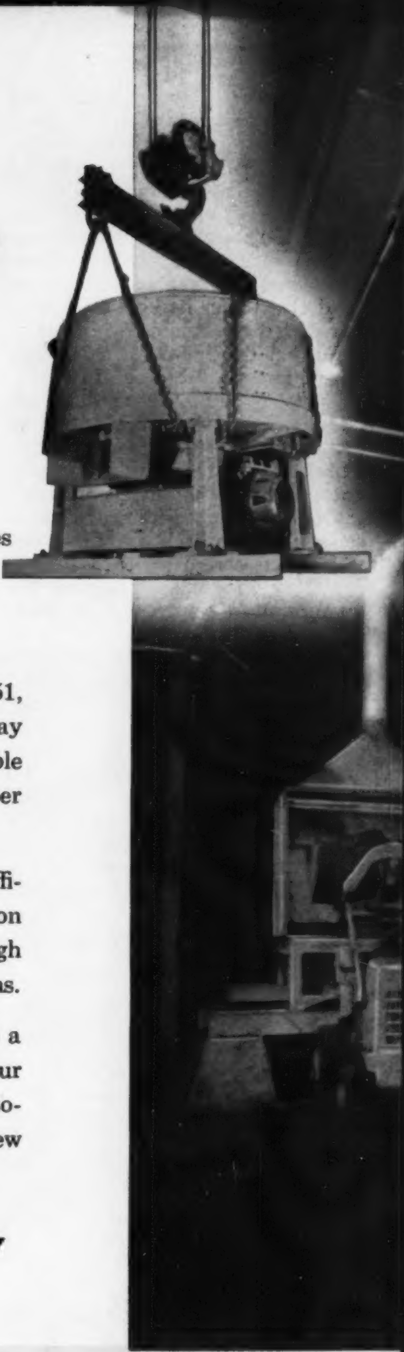
EASTERN CLAY PRODUCTS DEPT.

INTERNATIONAL MINERALS & CHEMICAL CORPORATION

Administrative Center, Old Orchard Road, Skokie, Illinois • ORchard 6-3000 17-60

Circle No. 153, Page 17

Would you TRADE IN your present Simpson Mixer for increased foundry profits?



How the Mix-Muller retirement plan benefits Mix-Muller users

Do you own a Simpson mixer comparable to the one described in the tables below? If you do . . . you may be pretty satisfied with your lot. Here's a dependable old machine still turning out production 10, 15, maybe even 20 years after you "wrote off" your investment.

Now, good National customers are *never* wrong. But . . . on June 5, 1951, that machine started to *owe* you money—production dollars. On that day nine years ago, the *Model F* Series Simpson Mix-Muller was made available to offer you 67% greater batch capacity . . . 100% more production per hour . . . 30% more overall mulling efficiency.

Whether you want increased production or greater sand preparation efficiency, these figures mean that every dollar you spend on a new Simpson Mix-Muller is an *investment* which you can expect *returned* to you through more profitable . . . up to 50% more profitable . . . sand preparing operations.

What's more—in 1960 National is prepared to make your transition to a modern F Series Mix-Muller as easy and as economical as possible. If your Simpson was built before 1951, you can *trade it in*—as you would your automobile. Why not call your National agent or write for details on the new *Mix-Muller retirement plan?*

NATIONAL ENGINEERING COMPANY
630 Machinery Hall Bldg., Chicago 6, Illinois
In Canada: 17 Queen St., East, Toronto 1

TRADE UP
for increased
Foundry Profits

IF YOUR SIMPSON MIXER IS OVER 20 YEARS OLD A MODERN F SERIES MIX-MULLER CAN DELIVER:

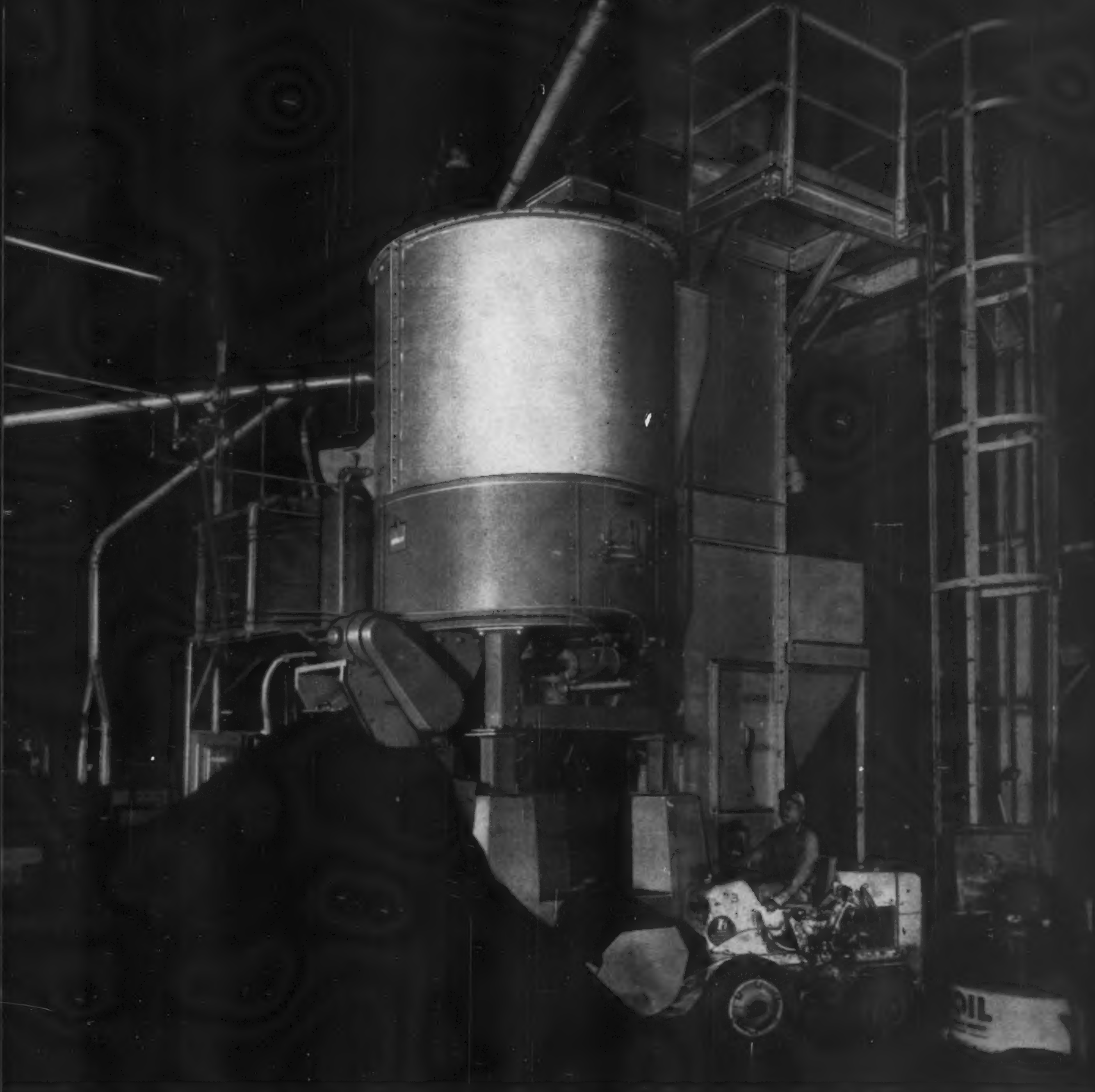
67% greater Batch Capacity
100% more Hourly Production
30% more Mulling Efficiency

THE FOUNDRYMAN'S CHOICE BY TO

PERFORMANCE

	1930 Simpson	Model F Mix-Muller	
Batch Capacity	1200 lbs. (max.)	2000 lbs. (min.)	67% more
Output Per Hour (G.I. Mold.)	12 tons (max.)	24 tons (min.)	100% more
Discharge Time	40 seconds	20 seconds	50% less
Mulling Efficiency	On basis of time required to develop sand characteristics compatible with modern foundry practice overall 2F efficiency is about . . .		30% greater
Equipment Cost (Per Ton/hr. of Sand Prepared)	Based on present day prices, the 2F Mix-Muller will turn out 100% more sand per hour at an equipment investment amounting to . . .		31% less cost per ton./hr.

MORE PRODUCTION



F300

CONSTRUCTION:

	1930 Simpson	Model F Mix-Muller
Muller Suspension	Rocker arms. 3 weights of mullers 700, 1000, 1600 lbs. Manual adjustment. Non-reversible.	Spring loaded—automatically adjusts to provide more pressure as sand increases in strength. Reversible.
Discharge Door	Hand fitted. No adjustment for wear.	Machined to close tolerance and equipped for wear adjustment. 100% larger opening.
Bearings	Sleeve.	Anti-friction throughout.
Drive	Open bevel, direct connected.	V-belt, self-contained, splash lubricated reducer.

BETTER BUILT

SERVICE AND OPERATING:

	1930 Simpson	Model F Mix-Muller
Lubricate	5 alemite fittings.	"One stop" centralized system for all interior components.
Plow Adjust	Wrench and hammer, from inside crib.	Can be adjusted from **top** of cross head.
Overhaul	Roll up sleeves. Crawl in mixer.	Roll out mullers and/or turret assy. through removable crib section—without dismantling hoods, hopperr, etc.

EASIER TO SERVICE

Write for details

MIX-MULLER RETIREMENT PLAN

Circle No. 154, Page 17

Managing Director of Modern Castings Announced

■ Harold E. Green has been named managing director of MODERN CASTINGS. Formerly vice-president and executive editor of Printers' Ink, weekly advertising magazine, Green came to his new post on March 1 from Standard Rate & Data Service, Inc. There he was executive editor of Media/scope, monthly advertising magazine.

Well known in business paper, advertising and educational fields, he

also has a background in association work, public relations and newspaper reporting.

Green is a past-president of the National Conference of Business Paper Editors, the Chicago Business Publications Association and the Industrial Editors Association of Chicago. Often a speaker before advertising clubs, he has lectured frequently on advertising and journalism at various colleges and universities. He is a graduate of the Medill School of Journalism, Northwestern University.

Eimco Announces "Determinant Tempering"

"Determinant Tempering" a patented thermal process for improving alloy steel and other castings, has been developed by The Eimco Corp., Salt Lake City. Castings cool in the mold to just below red heat, when they are shaken out. Castings are then immediately transferred in the rough to a car or batch type heat treat furnace already operating at the "S" curve to complete pearlite transformation. Air-cooling to room temperature follows.

／ METALGRAMS

. . . news about "Electromet" ferroalloys and metals

UNION CARBIDE METALS

APRIL, 1960

PLUNGING GROWS -- Ductile iron producers are showing more interest in the higher and more uniform magnesium recoveries obtained by plunging the magnesium-bearing alloy into molten iron in the ladle. Union Carbide Metals now offers two low-cost alloys for plunging -- "EM" magnesium-ferrosilicon (10 per cent magnesium) and "EM" alloy 55 (30 per cent magnesium). Both are specially sized for plunging. Among the advantages of plunging are magnesium recoveries up to 60 per cent, better structure control, less pyrotechnics, and lower costs. For further details, write for a new six-page folder, F-20,120.

* * *

FASTEST-DISSOLVING FERROCHROME -- Stainless steel melters continue to be impressed with the rapid solubility of the new "Simplex" low-carbon ferrochrome. In a typical test, 3,300 lbs. of the alloy (71.7 per cent chromium added) dissolved in a 15-ton heat after refurnacing in less than 25 minutes. In addition, 500 lbs. of "Simplex" ferrochrome added to the ladle during refurnacing dissolved before the ladle was half full. Get further information in a new six-page folder, F-20,112.

* * *

DOWN GOES THE IRON -- By reducing the iron content of aluminum-silicon alloy castings, high strengths can be obtained with good ductility. As a result, high-purity aluminum-silicon alloys are finding increased use in structural and rotating parts of jets and missiles. For practically iron-free silicon additions, Union Carbide Metals now offers a new 0.35 per cent maximum iron grade of silicon metal in addition to the 0.50 per cent maximum iron grade. In both grades, calcium, another undesirable element, is held to a maximum of 0.07 per cent. For further information, write for the Fall 1959 issue of UNION CARBIDE METALS REVIEW.

* * *

QUALITY IN QUANTITY -- Each of the more than 100 "Electromet" ferroalloys and metals is carefully inspected during every step of production. The aim: to make sure that each alloy meets close chemical specifications consistently. Samples are taken during raw material preparation, furnacing, blending and crushing, packing, storage, and shipping. During an average month at Union Carbide Metals' Marietta, Ohio, plant, more than 30,000 tests are made on over 10,000 samples. For further details, ask for the Summer 1959 issue of UNION CARBIDE METALS REVIEW.

* * *

NOTCHES AID CHARGING -- For years, iron foundrymen have been adding alloy additions to the cupola charge quickly and easily with "EM" briquets. Each briquet contains a definite weight of the alloying element, in one or two pound units. As an added convenience, all "EM" briquets are now furnished in notched form so that they can be split in half. Often, half a briquet is needed for accurate additions to small cupolas. For briquet specifications, write for F-20,086.

* * *

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

Build an idea file for improvement and profit. Circle numbers on literature request card (opposite page) for more information about these . . .

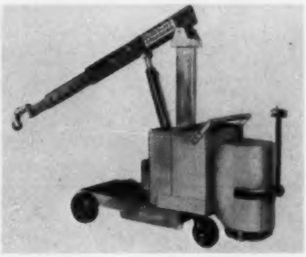
new products and processes

ELECTRIC FURNACE ACCESSORY GROUPS . . . lets one model electric furnace perform several operations, including salt bath, oil bath, melting, vertical muffle or crucible furnace. Util-

ity of furnace stems from flexible design concept. A basic furnace unit is used for all operations; conversions can be made even when the furnace is hot. Thermo Electric Mfg. Co.

For More Information, Circle No. 1, Page 17

MOBILE FLOOR CRANE . . . speeds production and cuts down on manpower. Designed for handling loads that are easier to transport with a hook, the unit eliminates problem of straddling a load before contact is made for lifting.



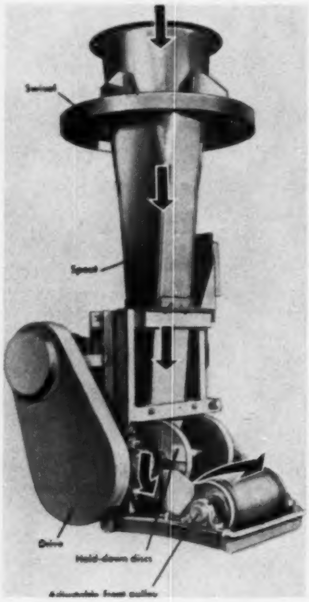
Capable of moving in four directions, the crane's power boom lifts and positions loads up to 5000 lb. Power-actuated boom can be lowered to 1-1/2 ft. and raised to 9 ft. Colson Corp.

For More Information, Circle No. 2, Page 17

PORCELAIN ENAMEL FINISHING SYSTEM . . . for magnesium is said to be virtually fool-proof method of "painting out" the possibility of corrosion in magnesium alloys. Key to system is a surface pretreatment which makes possible use on magnesium of standard lead-oxide or lithium-phosphate porcelain enamels already in use on other metals. System cannot be used with magnesium alloys of high aluminum content and of high total alloy content because these alloys contain low melting point eutectic. Can be used with magnesium alloys of lower aluminum content, magnesium-thorium alloys and magnesium-rare earth metal alloys. Dow Chemical Co.

For More Information, Circle No. 3, Page 17

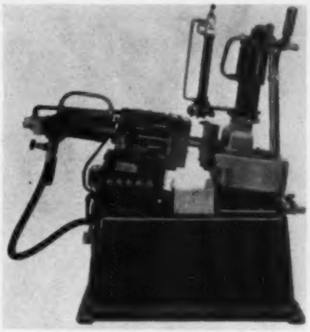
MATERIALS THROWING MACHINES . . . hurl free-flowing bulk materials into areas usually inaccessible by other mechanical means. Units have range of 90 ft and can pile to heights up to 35 ft above discharge point. Trajectory can be varied from 15 deg above horizontal



to maximum of 50 deg. Available in suspended, swiveling model and two portable, wheel-mounted units in belt widths of 14, 20 and 28 in. with capacities up to 70 tons per hr for materials weighing 50 lb per cu ft. Link-Belt Co.

For More Information, Circle No. 4, Page 17

SINGLE-CYCLE AUTOMATIC DIE CASTING MACHINE . . . is push-button controlled, with quick-attach electronic timer unit for single-cycle automatic operation. Has new solenoid-operated valve system, with two-way speed control for die setting and shockless operation. Two safety features are dual micro-



switches and a sensing device which retracts the toggles instantly if foreign matter gets between die faces. DCMT Sales Corp., Div. British Industries Corp.

For More Information, Circle No. 5, Page 17

PLASTIC LEAD SEAL . . . an all-purpose pipe joint and thread sealing compound comes in three mixtures. One for most industrial services including Freon, anhydrous ammonia, chemicals, distillates, LP and natural gas, petroleum products, steam, water and air; another for same services but of thicker consistency, especially recommended for pipe sizes over 1 in.; third contains special insoluble vehicles for such services as acetone, alcohol, glycerol, methyl, ethyl, ketone and amyl, butyl and ethyl acetate. Withstands pressures to 6000 psi and temperatures to 550 F. Crane Packing Co.

For More Information, Circle No. 6, Page 17

CORE HANDLING . . . walkie-rider carry-all truck available in capacities from 2000 to 10,000 lb is adaptable to a variety of applications. Can be furnished with 12 or 24-volt electrical sys-

tems and with overdrive for long fast hauls. Shelving is removable to allow carrying larger packages. Lewis-Shepard Products, Inc.

For More Information, Circle No. 7, Page 17

SELF-STORING AIR HOSE . . . eliminates hose reels and other storage facilities. Light weight reduces operator fatigue. Operates to 200 psi with maximum working length of 20 ft. Synflex Products Div., Samuel Moore & Co.

For More Information, Circle No. 8, Page 17

WATERLESS MOLDING SAND . . producing high-precision castings is pos-

sible with use of new sand binder. Dry binder is used with mix of 120 to 190 gfn sand, oil and a catalyst. Principal advantages are said to be reduction in gas on pour-off and use of finer sands, principal disadvantage is said to be higher initial cost of low clay content sand used. Archer-Daniels-Midland Co., Federal Foundry Supply Div.

For More Information, Circle No. 9, Page 17

CO_2 SHELL MOLDS . . . combine close-tolerance aspects of shell molding with time, labor and equipment saving features of CO_2 process. National Cylinder Gas Co.

For More Information, Circle No. 10, Page 17

EPOXY FOR 500 F . . . new epoxy resin has heat resistance up to operating temperature of 500 F. Material is said to retain elasticity at higher temperatures. Marblette Corp.

For More Information, Circle No. 11, Page 17

CORE WIRES . . . made of cord-like, resin-impregnated fiber glass break up during shakeout, eliminating resorting and reforming. Cord forms to any contour, will not deform and will not weld to casting. Archer-Daniels-Midland Co.

For More Information, Circle No. 12, Page 17

PLASTIC RUBBER . . . new material for pattern and core box manufacture or repair has been developed. Resists abrasion and erosion. Suitable for other foundry applications. Dike-O-Seal Inc.

For More Information, Circle No. 13, Page 17

CHECKS LOAD CELL SCALE . . . without test weights. Calibrating device is incorporated in electronic load cell scale during manufacture. At initial installation test it is set and locked at voltage equal to full dial capacity. Operator merely turns test switch to check calibration. Toledo Scale Div., Toledo Scale Corp.

For More Information, Circle No. 14, Page 17

INDOOR-OUTDOOR INFRARED HEATING . . . units reflect radiant heating to specific areas. Operating costs are said comparable to and often less than gas, coal and oil heating costs for open-area applications where over-all warmth is not necessary. Units are ceiling mounted, requiring no floor space. Maintenance reportedly is at minimum since lamps are not affected by splashing water, atmospheric changes or most acid and alkaline atmospheres. Luminator, Inc.

For More Information, Circle No. 15, Page 17

INFRARED DETECTOR . . . automatically measures and controls the temperature of moving or stationary objects without physical contact. Operation is completely remoted and unattended. Sensitivity is high (7 deg at 2000 F), and instrument response is automatic and continuous. Lowest standard range is 400 F and highest is 2000 F with higher ranges available for special applications. Radiation Electronics Co.

For More Information, Circle No. 16, Page 17

HIGH TEMPERATURE LUBRICANT . . . has excellent thermal stability and antiweld properties up to 750 F. Mate-

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9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213	225
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214	226
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products and processes

Continued from page 17

rial is a mixture of thermally stable silicone oil with a solid type lubricant blended to consistency of medium soft grease to prevent seizing and galling at bearing pressures over 100,000 psi. Bel-Ray Co.

For More Information, Circle No. 17, Page 17

HOT-MELT WATER SOLUBLE COMPOUND . . . developed for producing mandrels used in fabrication of reinforced plastic ducts, filament winding mandrels and pressure vessels with breakaway and washaway type molds. Features claimed: when liquidized can be cast to final shape without use of parting agents; when solidified has compressive strength up to 19,000 psi at temperature to 475 F; cast shape will retain dimensional accuracy from room temperature up to 475 F; molds or mandrels can be dissolved in water or remelted and material reused indefinitely. Rezolin, Inc.

For More Information, Circle No. 18, Page 17

SEQUENCE TIMING BOARD . . . for actuating three stopwatches at precisely the same instant designed for use in laboratory research, field action-studies, materials handling, production timing and traffic analyses. The unit times sequential steps with zero loss between

steps with no necessity to read timer hands while they are in motion. Procedure is to start with timer 1 at zero, timer 2 stopped at (and ready to flyback from) any point other than zero and timer 3 in motion. Heuer Timer Corp.

For More Information, Circle No. 19, Page 17

MAGNETIC STIRRER . . . can handle up to six vessels, each of 1000-millimeter capacity, at predetermined speeds for indefinite periods of time with identical agitation. Unit measures 7x12x18 in. and has variable stirring action from slow mixing to high-speed agitation. Labline, Inc.

For More Information, Circle No. 20, Page 17

MICROSCOPIC GLASS BEADS . . . said to be particularly effective in clean-

Continued on page 20

B & P WIRE STRAIGHTENERS handle random lengths of used core wires and rods quickly and economically. **WIRE CUTTERS** by B & P are ideal for rods, wires and band iron.

B & P ELECTRIC RIDDLES are manufactured in four models to save money on every molding or core making job. They cut costly man hours . . . speed production.

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Compact, easy to use FOUNDRY MITES will perform 1001 foundry jobs better and save costly man hours too. With nearly 50% of casting production cost directly chargeable to labor, today's foundrymen cannot afford to overlook the advantages offered by this versatile line of equipment. Advantages in manpower, time, material and quality.

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SCREENARATOR'S capacity, flexibility, performance and dependability have made them the most widely used conditioning units of any size in the foundry industry. Low cost Screenarators in three models provide from 20 to 45 tons of sand per hour.

Circle No. 157, Page 17

Continued from page 18

ing and blasting by various wet and dry methods on a wide range of metals and materials. Said to be adapted to high precision cleaning and blasting such as treatment of delicate parts and surface, preparation of soft and hard metals for plating and other finishing and in operations where low metal removal rate is important. Microbeads, Inc., subsidiary of Cataphote Corp.

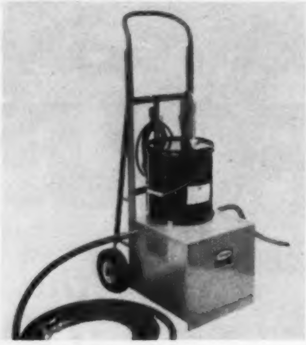
For More Information, Circle No. 21, Page 17

PIERCED METAL SHEET . . . made of carbon steel, stainless steel, copper, brass or aluminum is said to last up to three times longer than perforated met-

al. Sheet thickness can be made up to seven times hole diameter. Working side, which has the smaller end of the tapered holes, has humps that act in shovel-like fashion to guide material to the openings. Available in sheets up to 31 in. wide or formed into sheared shapes, cones, segments and cylinders. It can be tensioned and made with clamping grooves or turned edges. Cross Perforated Metals, National-Standard Co.

For More Information, Circle No. 22, Page 17

PORTABLE DUST CONTROL SYSTEM . . . designed for single point dust suppression or controlled wetting of raw materials. Can control dust at mullers, shakeouts, truck unloading bins and other dust generating points. System includes a proportioner, mixing chamber



and auxiliary controls mounted on hand truck. Proportioner can be factory adjusted to dispense from 1 to 11 gallons per min of non-toxic dust suppression solution. Hand truck can be removed and installation made permanent unit. Four models. Johnson-March Corp.

For More Information, Circle No. 23, Page 17

PORTABLE SCALE TRUCK . . . allows commodities to be moved and weighed simultaneously eliminating multiple handling of loads with consequent time savings. Hydraulic footlift truck has a 3000-lb capacity and is built with spe-

cial lifting angles to hold the scale. Use of scale as integral part of lift truck eliminates weighing of truck itself and supplies a net weight of material handled. Lewis-Shepard Products, Inc.

For More Information, Circle No. 24, Page 17

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Among the many fleet owners is the CADILLAC MALLEABLE IRON CO. of Cadillac, Michigan, who today are using 5 "PAYLOADER" tractor-shovels. Their first "PAYLOADER" was purchased back in 1945. Mr. Whaley, company treasurer, says, "We wouldn't have used "PAYLOADER" units exclusively for 15 years if we didn't like the equipment."

The "PAYLOADER" units are used to unload sand from boxcars, haul sand and castings to shakeout hopper, haul sand to muller and back to molding stations. In addition the machines also handle refuse, iron scrap and coke.

If you have a bulk material handling problem in your plant, see what a flexible, versatile "PAYLOADER" can do before you install any fixed material handling system. There are 20 models to choose from to fit your exact requirements. Send for complete details.

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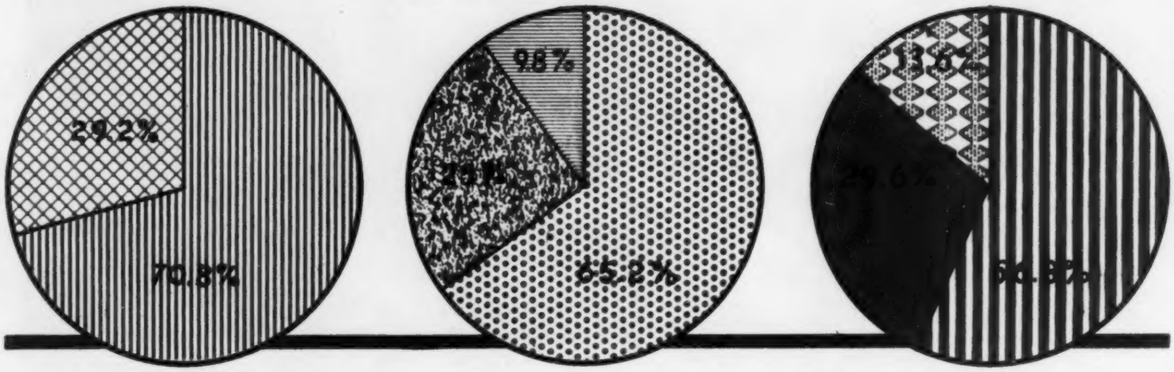
Circle No. 159, Page 17

Ferrous and Non-Ferrous Metalcasting Industry . . .

. . . Employees and Foundries

Total employees in foundries employing 20 or more



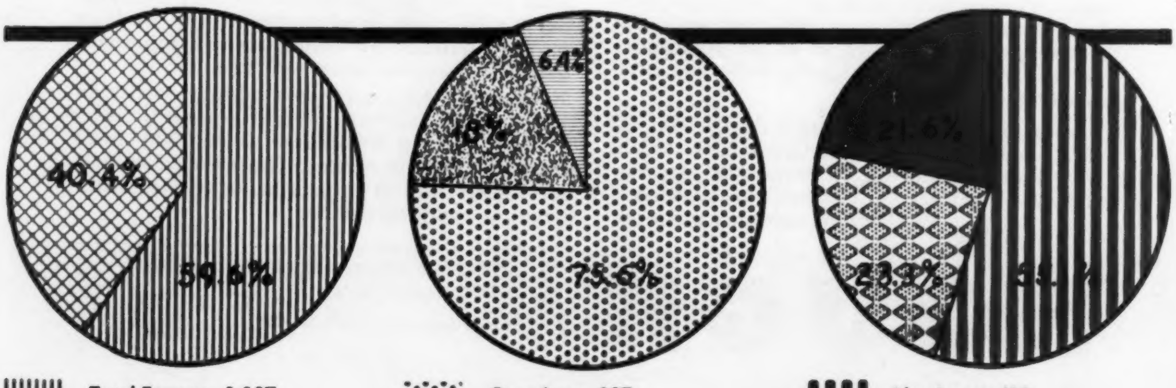
Total Ferrous—204,880	Gray Iron—133,725
Total Non-Ferrous—84,277	Malleable— 20,228
	Steel — 50,927

Aluminum—47,862
Brass, Bronze, Copper, Copper base alloy—11,412
Other Non-Ferrous—25,003

■ These charts present the total number of employees and foundries in the United States comprising the ferrous and non-ferrous castings industry. The three "pie charts" above show: first, the proportional number of employees within the two classifications; second, a breakdown of employees involved in making (1) gray iron, (2) malleable and (3) steel castings; and third, a breakdown of employees engaged in production of (1) aluminum; (2) brass, bronze, copper and copper base alloy; and (3) other non-ferrous castings.

The three charts below show proportions of foundries in these same categories. Source for this material is the Dun & Bradstreet 1960 Metalworking Directory, published by Dun & Bradstreet, Inc., New York.

Total foundries employing 20 or more



Total Ferrous—1,107	Gray Iron—837
Total Non-Ferrous—747	Malleable— 71
	Steel —199

Aluminum—412
Brass, Bronze, Copper, Copper base alloy—174
Other Non-Ferrous—161

the editor's report

by Jack Schaum

Conversion of cupola iron into steel in the ladle . . . may sound to some like an alchemist's dream . . . but not to D. L. Bryant, Australian foundryman, who has succeeded in turning this bit of metallurgical artistry. The process starts with the tapping of about 1500 lb of cupola iron into an acid lined reaction ladle fitted with a lid. Then a water-cooled jet delivers oxygen at supersonic speed vertically onto surface of molten iron. Fifteen minutes and 1400 cu ft of oxygen later a mild steel suited for casting is tapped from tap hole near bottom of reaction vessel. Process can help iron foundries having occasional desire to make steel castings with a minimum of equipment investment.

Did you know that flue gas . . . can be used to harden sodium silicate bonded sand cores and molds instead of CO_2? Flue gas is ideal because of its acidity derived from CO_2 and S content. Your only problem is to figure out how you're going to collect, compress and deliver it to gassing stations.

Kiss gating . . . no, it's not a new vice . . . but a darned good way of introducing clean metal into mold cavity plus making it easy to break castings off the gating system with a sharp hammer blow. Gate runs in cope and just barely makes contact with casting cavity (or cavities) in the drag. Works especially good when you have a multiplicity of small brass and bronze castings attached to runner system.

Ever start up . . . a continuous sand system in a foundry on Monday morning? You really need a strong index digit to push all the buttons and a good set of directions for pushing them in the right sequence. Or else you will have sand running down the molders' necks and will be digging the muller from under a sand dune. Here's a typical succession of equipment start-ups that **must** follow each other in the right order: 1) exhaust blower on roof . . . 2) feed belt to storage bin . . . 3) aerator on belt ahead of storage bin . . . 4) vibrating screen for removing metal and core butts from shakeout sand . . . 5) belt elevator . . . 6) shakeout conveyor belt . . . 7) overflow conveyor belt . . . 8) distribution belt over molding stations . . . 9) aerator on distribution belt . . . 10) small metal particle separator . . . 11) bucket elevator . . . 12) muller . . . 13) feed belt to muller. Just to be on the safe side, most foundries also interlock the push buttons so the second button won't operate until the first one has been pushed.

One man's by-product is another man's product . . . in this complex industrial age of ours. So a by-product of powdered-coal-fired steam-electric power plants is finding its way into the metalcasting industry. The by-product is an abrasive grit for air or airless blast cleaning of non-ferrous castings. Because of its sharp and angular nature, it imparts a finely etched appearance to the surface of castings. Said to cut fast, have long life, be impervious to moisture and present no silicosis hazard.

On-the-job medical care . . . is an attractive fringe benefit that keeps employees happy and healthy at Stockham Valves & Fittings, Inc., Birmingham, Ala. Two dentists, a doctor, and 4 nurses are on duty every day in their extensive medical clinic. Each employee receives an annual physical examination including chest x-ray. Medical care is provided only in the clinic and only during working hours. Program is also big help in reducing absenteeism.

New Look . . . in foundry superintendent's office. Nowadays when you walk into the super's office you can't see the walls because they are covered with quality-control charts. Every department and every operation contributing its influence on scrap generation is kept under close surveillance by the superintendent and quality-control engineers. At one quick glance you can see on the graphs what element is drifting out of line and pull it back in before it's reflected in substandard castings. Or if you wonder what happened last Wednesday in the melting department. . . there it is. Recommended reading on this subject is "Specialized Foundry Statistical Controls Improve Customer Satisfaction" by B. M. Appleman, Texas Foundries, Lufkin, Texas. They saved $80,000 in one year with such a program!

to make a TON of castings . . .

How many tons of materials . . . and How far do they move

by Jack H. Schaum/*Ed.*

Do you realize that next to making good castings your biggest job in the foundry is moving materials! Foundrymen operate a gigantic merry-go-round of raw materials and supplies constantly on the move. Your efficiency in carrying out this important facet of daily operations may very well decide whether your year-end net is written in red or black ink.

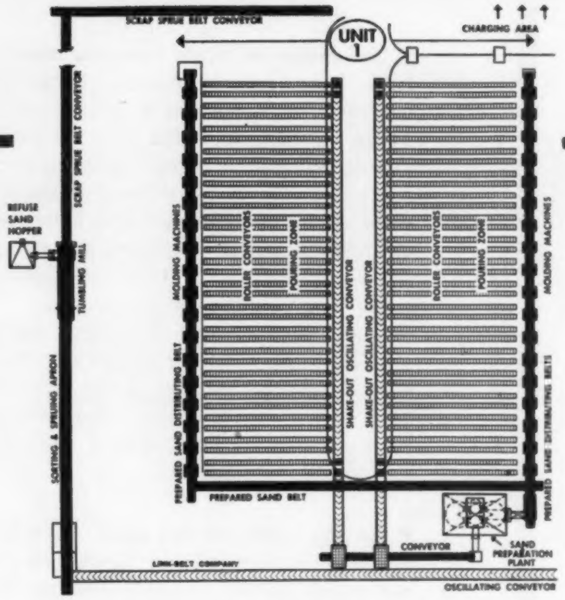
For years now it has been a foundryman's rule-of-thumb that you had to move 200 tons of materials to make a ton of finished castings! Since no substantial proof of this claim has ever been forthcoming, Modern Castings decided to make a detailed study of materials handling in a modern foundry and find out just what this figure should be.

Perhaps 200 tons of materials must be moved in an inefficient antiquated foundry system. If so, then the savings possible through modernization are staggering . . . because the Modern Castings study revealed that the job of producing a ton of finished castings can be done by *moving only 90 tons of materials!* Even with this remarkable reduction, moving 90 tons is a prodigious assignment when multiplied by your daily production tonnage.

To dramatically demonstrate the magnitude of this never-ending profit parasite, Modern Castings presents here a detailed study made in one of the newest and most modern metalcasting plants in the United States . . . the Ewart Foundry of Link-Belt Co. at Indianapolis. Here is a plant built to meet and surpass all previous standards for production of quality malleable iron castings. But beyond this the foundry layout was planned as a show place to demonstrate the epitome of efficient materials handling . . . an achievement made possible because Link-Belt Co. is one of the leading producers of equipment for handling foundry materials.

This article is aimed at answering two fundamental questions: How many tons of raw materials must be moved to make a ton of finished castings . . . and how far must they be moved?

To develop these answers all important ingredients contributing to the production of finished castings were weighed and the distances traveled were measured. All data collected have been extrapolated to a common denominator of one ton of finished castings.



Partial floor plan, Ewart Foundry, Link-Belt Co., Indianapolis, one of newest and most modern metalcasting plants in the United States.

The finished castings in this case are malleable iron chain links with a shipping weight of 0.629 lb apiece.

We will now follow the devious paths traced by the complex of materials and operations that make a casting. At the start these materials divide themselves conveniently into eight facets of production: 1) molding sand, 2) coremaking, 3) molding operations, 4) melting, 5) pouring, 6) shakeout, spruing and hard iron cleaning, 7) heat treatment, and 8) soft iron cleaning, inspection and shipping.

1 Molding Sand

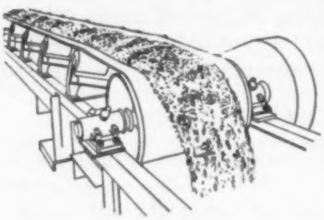
With chain links weighing 0.629 lb apiece, 3180 castings will have to be made to total one ton. Ten links are made per mold so 318 molds must be rammed. Each mold contains 83 lb of green sand and 0.83 lb of cores. This totals 26,394 lb of green sand and 264 lb of core sand. In making 318 molds an additional 5280 lb of green sand is needed to make up for spillage at molding stations.

Green sand therefore totals 31,674 lb. Included in this weight are 160 lb of additives and 126 lb of new sand. Only these two small quantities move from raw material storage to the muller since the balance is constantly "in process."

New sand arrives in boxcars and is carried by

front-end loader 60 ft to storage bins. Front-end loader moves 126 lb of new sand 150 ft and dumps it through a hole in floor onto

spill-sand belt conveyor. Sand then moves 215 ft via three different belts to shakeout oscillating conveyor.



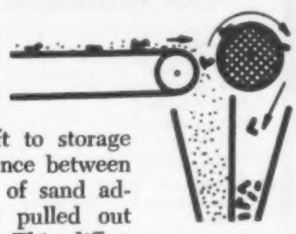
Here new sand meets up with the mold shakeout operation and joins 26,784 lb of hot shakeout sand including 264 lb of core sand. With a jolt-squeeze molding operation fed from an overhead hopper there is about 20 per cent sand spillage at each molding station. For 318 molds this amounts to 5280 lb. This spill sand drops 4 ft through a grate under molding machines onto a belt conveyor. Conveyor

carries spill sand 70 ft and drops it onto transfer conveyor. This belt in turn moves sand 50 horizontal feet and 9 vertical feet to the shakeout oscillating conveyor.

This oscillating conveyor is over 300 ft long.

The oscillating shakeout conveyor is a rugged work horse moving 5280 lb of spill sand and 26,784 of hot shakeout sand, plus 4543 lb of hot castings and sprue 90 ft to the shakeout screen.

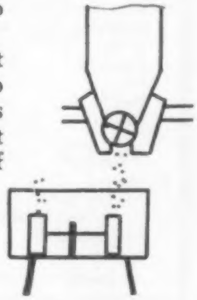
Shakeout screen separates sand from castings with sand moving about 4 ft across screen and dropping 4 ft onto an oscillating conveyor which is 20 ft long and discharges onto belt conveyor. This belt carries sand 25 ft and up 8 ft over a magnetic pulley to remove tramp iron. Sand then drops 10 ft into the boot of a double bucket elevator. Elevator (rated at 225 tons/hr) raises 31,514 lb[1] of sand 57 ft to storage bin over mullers. Difference between 32,064 lb and 31,514 lb of sand adheres to castings or is pulled out through exhaust system. This difference is 550 lb which is equal to weight of core sand, new sand and additives entering the system.



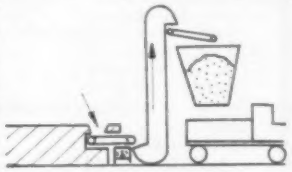
Sand additives, palletized in sacks, arrive at the plant by truck or railroad. Fork truck is used to transfer the additives 50 ft to storage. To make 318 molds, 160 lb of additives are mixed into 31,514 lb of green sand. Fork truck carries this quantity 300 ft to a floor level trap door near muller. Sand additives drop 5 ft into a pneumatic chamber. Compressed air at 9 lb/sq. in. deliver 160 lb of binders up 10 ft and over 10 ft through a pipe to the muller in eight 20-lb batches.

Muller reconditions the sand in 4000-lb batches. In order to prepare the 31,674 lb needed for 318 molds, 31,514 lb feed by gravity 46 ft down into muller from overhead storage bin. Eight batches are mixed with the 160 lb of additives.

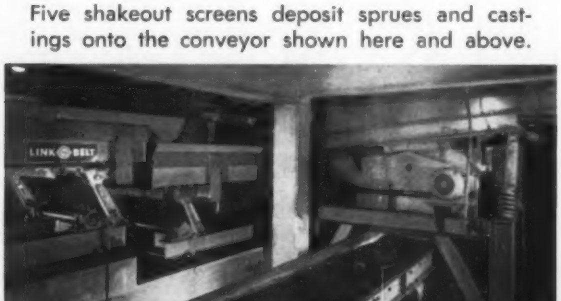
Conditioned sand discharges 7 ft down into a hopper and through to conveyor belt. This belt moves sand 10 ft horizontally and 8 ft downward to boot at bottom of bucket elevator. As fast as the molding sand arrives in the boot the buckets elevate the 31,674 lb of sand 42 ft to a large overhead storage hopper.



The sand is now ready for delivery to the molding stations. Gravity supplies the power needed to move the sand down 11 ft through a revivifier onto the main horizontal distribution belt traveling continuously above the molding stations. Diversion plows drop down on the belt and plow the sand into storage hoppers lo-



Five shakeout screens deposit sprues and castings onto the conveyor shown here and above.



Distributing belt conveyor serving 18 molders supplies sand according to individual needs.

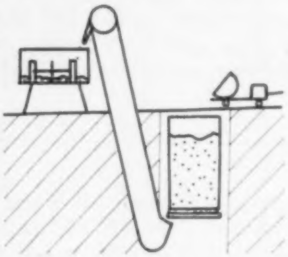
TABLE I—MATERIALS MOVED TO MAKE A TON OF MALLEABLE IRON CASTINGS

Material	Weight (lb)	Distance Moved (feet) Horizontal	Vertical
1—Molding Sand			
New Sand	126	653	219
Sand Additives	160	553	101
Shakeout Sand	26,784	328	211
Spill Sand	5280	400	216
Subtotal	32,350	1934	747
2—Coremaking			
Sand delivery from box car to muller	264	30	38
Core sand mix to core benches	264	50	5
Coremaking	264	5	1
Green core transfer	264	45	
Core baking	264	6	60
Core transfer to inspection	264	40	1
Inspection and racking	264	16	
Core delivery to molding station	264	355	
Core setting	264	143	7
Subtotal	2376	690	112
3—Molding Operations			
Matchplate:			
Delivery to molding stations	60	85	10
Return to storage	60	85	10
Delivery to molding station	54	100	
Snap Flask:			
Return to storage	54	100	
Flasks	8586	12	3
Matchplates	9540	2	1
Bottom boards	1590	49	7
Squeeze boards	1590	2	2
Mold weights	12,720	12	3
Subtotal	34,254	447	36
4—Melting			
Steel scrap	2201	200	100
Malleable sprue and scrap	2483	115	60
Coke	420	115	80
Limestone	190	115	80
Air	2421	150	
Slag	79	2675	35
Transfer to air furnace	4543	25	3
Coal	320	150	30
Subtotal	12,657	3545	388
5—Pouring			
Transfer ladle	8000	1320	64
Molten iron transfer	4543	660	88
Pouring ladles	3600	10	
Pouring iron	4543	10	1
Subtotal	20,686	1975	153
6—Shakeout and Cleaning			
Shakeout	4543	98	7
Transfer to spruing	4543	300	3
Spruing	4543	50	6
Sprue cleaning	2248	75	13
Sprue delivery to scrap yard	2248	300	23
Sorting Castings	2295	10	
Tote box movements	300	140	2
Cleaning Castings	2295	93	8
Delivery to grinding department	2295	85	
Grinding	2295	6	6
Casting rejects	174	300	1
Subtotal	27,779	1457	69
7—Heat Treating			
Castings moving to pot loading stations	2122	140	
Loading pots	2122		3
Packing gravel pots	600		6
Moving to mudding station	5122	50	
Moving pots to annealing ovens	5122	125	
Removing pots from annealing ovens	5122	40	
Moving pots to shakeout & dumping	5122	50	4
Shakeout	5122	12	6
Castings to weigh station	2061	80	11
Castings to cleaning room	2061	130	6
Subtotal	34,576	627	36
8—Final Cleaning			
Casting cleaning	2061		6
Sorting	2061	6	
Inspection	2061	40	2
Casting rejects	61	400	
Weighing	2000	40	
Delivery to storage and shipping	2000	40	4
Subtotal	10,244	526	12
Grand Total	174,922	9716	1439

cated under the belt at each molding station. Some 31,674 lb of sand travels an average of 135 ft on this belt and drops 10 ft into hoppers at molding stations. Section 1 in Table 1 summarizes these movements.

2 Coremaking

To make 318 molds containing 3180 chain links, a total of 264 lb of cores are needed. Core sand arrives by box car on a siding. A front end loader carries sand 20 ft and dumps it into a chute where it slides to basement storage bin. Bucket elevator raises sand 18 ft and dumps it into muller. Core mix discharges through a riddle into a wheelbarrow. Prepared sand is wheeled an average of 50 ft to core benches. Cores are hand rammed and set on a 10-lb plate which is in turn placed on a conveyor belt. Belt moves 45 ft to vertical core oven where cores make 60-ft round trip in baking process. Baked cores then travel 40 ft on roller conveyor to inspection. Inspected cores are racked in tote boxes and delivered to molding stations 355 ft away on manually pushed core buggies. Section 2 in Table 1 summarizes these movements.



3 Molding Operation

Before molding can commence, two 30-lb matchplates must be delivered to the two molders assigned to making the 318 molds. Plates are moved by hand truck from storage in basement of foundry to the molding station—a distance of 85 horizontal and 10 vertical feet. Two sets of cope and drag flasks (54 lb) must be fitted to the matchplates and hand trucked 100 ft to the molding stations. The previously used matchplates and flasks are brought back to storage on the return trip.

At the jolt-squeeze station power is supplied by the skilled molder. To make each mold he must handle several times a 15-lb cope snap flask, a 30-lb matchplate, a 12-lb drag snap flask, a 5-lb bottom board and 83 lb of sand. For 318 molds this adds up to 8586 lb of flasks, 9540 lb of matchplates, 1590 lb of bottom boards, 26,394 lb of sand, 264 lb of cores and 1590 lb of squeeze boards. Seventeen operations performed with these materials in making 318 molds add up to 413,025 ft-lb of work! At the rate of a mold every two minutes, two molders can make these 318 molds in 5.3 hours.

The 84-lb sand mold and its 5-lb bottom board glide on a gravity roller conveyor about 20 ft to the pouring station. A weight shifter carries 40-lb weights some 10 ft and sets them on each mold just before filling with 14.3 lb of molten metal. Shortly after pouring, the weights are removed and molds roll another 20 ft to be dumped through a hole in floor onto an oscillating conveyor. From molding station to dumping, material movements total: 26,712 lb of sand move 40 horizontal ft and drop 6 ft; 12,720 lb of mold weights travel 12 ft forward and 3 vertical ft; 4543 lb of metal travel 23 ft and drop 3 ft; and 1590 lb of bottom boards make an 80-ft round trip moving up and down 5 ft.

As mentioned earlier, the 90-ft shakeout oscillating conveyor carries spill sand, castings and sprue to the hot shakeout sand, hot shakeout screen. Here sand and metal part company. Shakeout sand travel from this point back to storage has already been described. This completes the movements of molding materials. Table 1, Section 3 summarizes the weights and distances involved.

After cooling, molds and castings are discharged onto oscillating conveyor running under floor, and then move to shakeout screen.

4 Melting

The first scene of activity in the melting department is centered in the scrap storage yard located behind the cupolas.

Figure 1 has been prepared to show the materials which must be charged into a cupola and what happens to them in the process of making a ton of finished malleable iron castings. You can see why a total of 4684 lb of scrap steel, sprue and malleable scrap are needed to provide 2000 lb of castings for shipment. The percentage data refers to the per cent that each particular item amounts to in terms of this total metal charge.

The melting depart-

Ten-ton ovehead crane spans full width of material storage and charging yard. Raw materials arrive in freight cars in covered yard area.

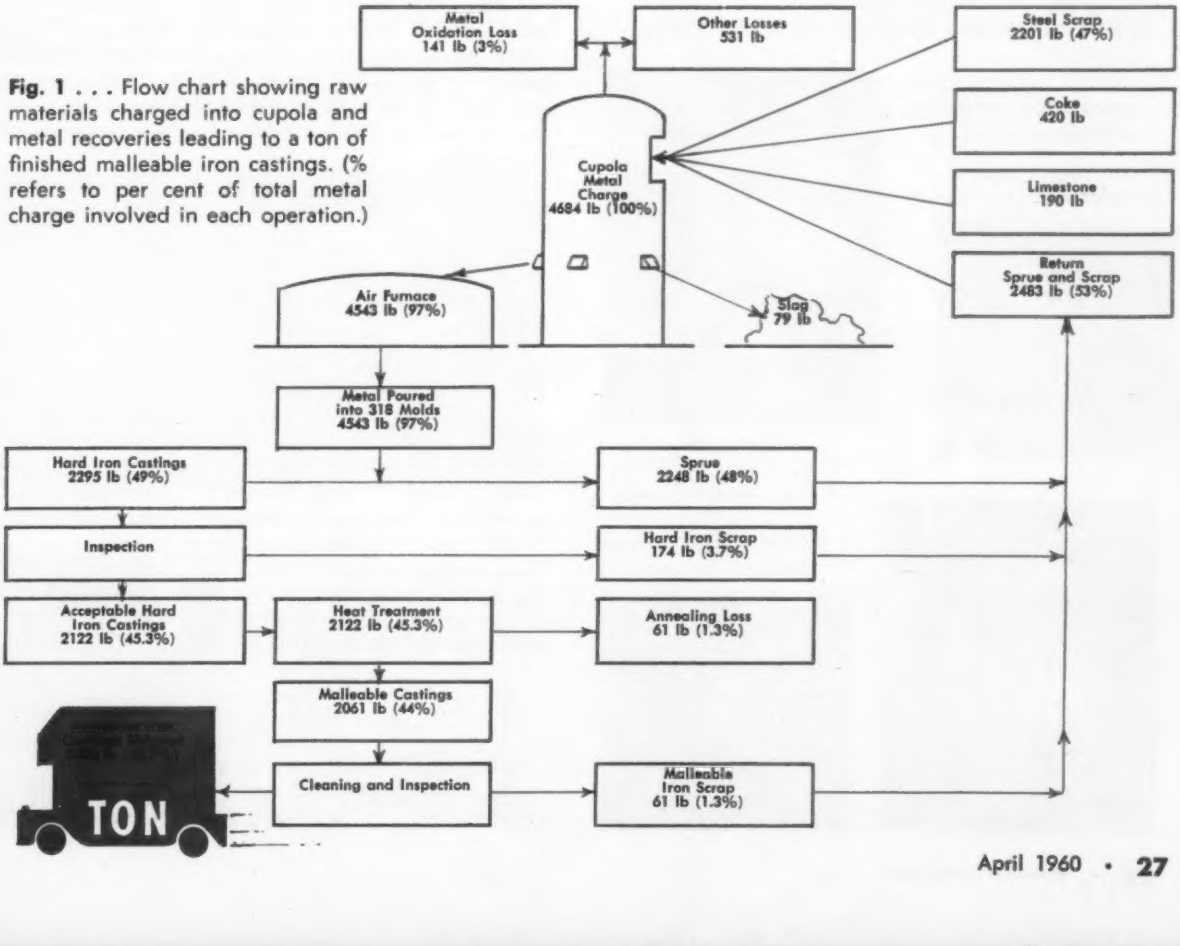
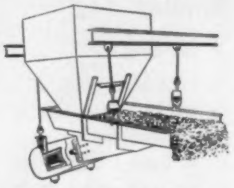


Fig. 1 . . . Flow chart showing raw materials charged into cupola and metal recoveries leading to a ton of finished malleable iron castings. (% refers to per cent of total metal charge involved in each operation.)

ment raw materials—steel scrap, coke, limestone and coal—arrive in freight cars. A 10-ton overhead crane equipped with an electro-magnet grabs steel scrap in gondola car, raises it 15 ft, carries it 40 ft and drops it 25 ft into a storage bin. A clamshell bucket attachment is used on the crane to transfer coke, coal and limestone to their storage bins 50 feet away.



In making up cupola charges a vibrator moves 420 lb of coke and 190 lb of limestone 5 ft from bins and drops it 10 ft into weight hopper. To the weigh hopper via crane comes 2201 lb of steel scrap some 100 ft and 2483 lb of malleable sprue and scrap about 55 ft. This amount of material actually represents two charges which drop 10 ft into charge buckets. A transfer car moves the buckets 45 ft to a hoist which raises them 30 ft to the charge opening where they are automatically dumped into the cupola.

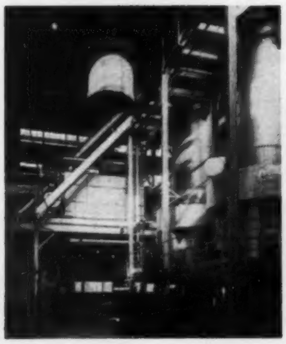
Not to be overlooked is the 2421 lb of air that must be transported 150 ft and blown through the tuyeres to achieve combustion in the cupola.

Coming out the slag spout is 79 lb of slag which is granulated in a stream of water. A trough carries the slag over 20 ft and down 20 ft into a tank from which a flight conveyor moves it up 15 ft and out 15 ft to a dump truck. Truck hauls slag 2640 ft to the dump area.

Molten metal coming out the tap spout flows over 25 ft and down 3 ft into the air furnace. Because of melting losses only 4543 lb reaches the air furnace. During the time the iron remains here for superheating and composition adjustment, about 320 lb of coal are burned. This quantity of coal has moved 50 horizontal ft and 30 vertical ft getting from freight car to storage bin via clamshell bucket. Now it is pulverized and blown 100 ft to the air furnace burner. Section 4 in Table 1 details the weights and distances involved.

Electric magnet drops scrap into automatic charging hopper.

Electrically operated transfer car.

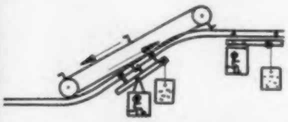


Charging bucket lifted from transfer car.

Hot iron trough from cupola to furnace.

5 Pouring

Molten iron is tapped from the air furnance into transfer ladles weighing 2000 lb and holding 1200 lb of metal. To deliver the 4543 lb of metal needed to pour 318 molds at the pouring stations, the transfer ladle has to make four trips. This operation involves traveling 165 ft by monorail from furnace to pouring stations with 4543 lb of metal and 8000 lb of ladles . . . four round trips returning each time with 8000 lb of empty ladles . . . all at a height of about 8 ft above floor level.

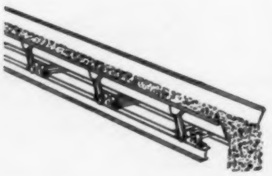


Duplex melting system

After pouring molds, operators dump castings on oscillating conveyor beneath the grating.

Metal flows from transfer ladle to pouring ladles weighing 200 lb and holding 250 lb. Pour-off man moves an average of 10 ft. To pour off 318 molds, 18 ladles of iron are needed. So 3600 lb of ladles as well as 4543 lb of iron are being moved about during pouring. Section 5 in Table 1 summarizes the molten metal movements.

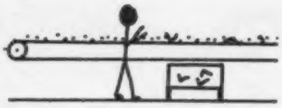
6 Shakeout, Spruing and Hard Iron Cleaning



Dumping the poured molds onto the shakeout oscillating conveyor has already been described with respect to sand movements. The 4543 lb of hot castings travel this same 90 ft in company with the sand until they cross the vibrating shakeout screen. Castings move 8 ft across the shakeout and drop 1 ft onto an oscillating conveyor. For 300 ft they move under the foundry floor gradually rising 3 ft to be discharged on an apron conveyor. This conveyor travels up 6 ft

Castings are sprued, sorted on apron conveyor and sent on for cleaning, annealing.

and 50 ft past the spruing stations where 2248 lb of gates and risers are broken off the castings. The remaining 2295 lb of castings are sorted into the boxes. But sprue rides on 45 ft further to the sprue mill where it is cleaned of sand. Thirty feet further the clean sprue drops onto a belt conveyor for a 23-ft climb and 300-ft trip to the scrap yard for recharging into the cupola. Tote boxes weighing 300 lb and holding the 2295 lb of hard iron castings are trucked by forked lift about 70 ft to an abrasive cleaning machine. Clean castnigs discharge onto an oscilliating conveyor which drops them into barrels 20 ft away. Eight barrels of castings totaling 2295 lb are hand trucked to hard iron grinding. Inspection eliminates an average of 174 lb of castings which are carried by fork-lift truck 300 ft to the scrap yard. Section 6 in Table 1 summarizes the casting movements through hard iron cleaning.

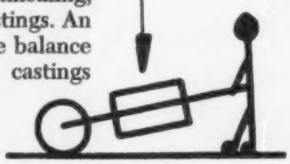


7 Heat Treatment

There now remains 2122 lb of hard iron castings eligible for heat treatment. These are transported in barrels 140 ft to the pot loading station in the annealing department. This department has not yet been modernized so movements may appear a little primitive compared to those described up to this point. About 265 lb of castings are dumped into an annealing pot weighing 300 lb. Then 75 lb of red flint gravel are packed around the castings. Eight pots are required. This adds up to a total weight of 2122 lb of castings, 2400 lb of pots and 600 lb of gravel to be moved 50 ft to mudding station, 125 ft into annealing oven, 40 ft out from oven to cool after annealing and 50 ft to shakeout.

Annealing department has not yet been modernized, from annealing oven, castings move to shakeout.

Pots are bottom dumped 4 ft onto shakeout screen where the 600 lb of gravel and 61 lb of metallic oxide scale, developed during annealing, are separated from the castings. An apron conveyor carries the balance of 2061 lb of annealed castings over 60 ft and up 11 ft to drop into wheelbarrows. A worker wheels castings 20 ft to weigh scale and another 20 ft where he dumps them onto a slat elevator. On the elevator castings travel 30 horizontal ft and 6 vertical ft and again discharge into wheelbarrows. From this point they are wheeled 80 ft to the Soft Iron Cleaning, Inspection and Shipping Department. Section 7 in Table 1 summarizes movements through the Heat Treatment Department.



8 Soft Iron Cleaning, Inspection and Shipping

The 2061 lb of castings are dumped into a shot-blast cleaner and discharged onto a sorting table. Castings are sorted into tote pans weighing 20 lb and holding 80 lb each. So 26 tote-pan loads roll by gravity conveyor to the inspection area where an average of 61 lb of castings are scrapped and sent to storage yard for remelting. The final 2000 lb of inspected castings are transferred in barrels 40 ft to weigh scales and another 40 ft to storage and shipping . . . the final goal has been reached—one ton of finished malleable iron castings.

This achievement has required:

- The movement of almost 90 tons of foundry materials . . .
- through a complex maze over two miles long . . .
- up and down 1553 feet . . .
- with 44 different units of materials handling equipment . . .
- driven by 700 hp of energy . . .
- plus some 55 separate manual operations . . .
- a lucid demonstration of the staggering materials handling challenges to be met in your everyday foundry complex.

Remember this study was made in a new foundry designed for top efficiency in materials handling. How would your shop measure up in a similar analysis?

TABLE 2—HORSE POWER OF MECHANICAL EQUIPMENT USED IN MAKING A TON OF FINISHED MALLEABLE IRON CASTINGS

	Number of Units	Total HP
Front End Loaders	2	70
Fork Lift Trucks	3	100
Dump Truck	1	3
Transfer Car	1	3
Overhead Crane	1	80
Belt Conveyors	10	45½
Oscillating Conveyors	5	104½
Apron Conveyors	2	6
Vibrating Conveyor	1	1½
Flight Conveyor	1	2
Monorail Conveyor	1	3½
Shakeout Screens	2	22½
Gravity Roller Conveyors	3	
Bucket Elevators	4	50
Slat Elevator	1	2
Cupola Hoist	1	33
Skip Hoist	1	3
Pneumatic Conveyor	1	30
Vertical Core Oven	1	19
Cupola Air Blower	1	100
Coal Blower	1	20
	44	698½

Acknowledgment: Particular thanks are due Carl Schopp, assistant general superintendent, and R. C. Johnson, methods department engineer, Ewart Foundry, Link Belt Co., Indianapolis, for their extensive assistance in providing information for this study.

"we make castings for foundries"

By WALTER R. COLSMANN
Sarcol Foundry & Pattern Corp.
Chicago, Ill.

New-found metalcasting abilities are literally permitting the foundry industry to lift itself up by its own bootstraps.

The die casting, permanent mold and shell molding processes have certain economic limitations imposed by expensive machining and die-sinking operations required in making metal dies, permanent molds, patterns and core boxes. Sarcol Foundry & Pattern Corp., Chicago, has found it possible to short-cut these time-consuming, cost-raising operations by using precision cast-to-size foundry techniques.

Efforts, heretofore using conventional processes, fell short of the dimensional precision required so often by astute casting buyers. Even baked zircon molds were not fully adequate to meet industry needs. Realizing the limitations of standard methods, Sarcol investigated a new foundry technique, the Shaw process, which held promise of casting to previously unattainable dimensional accuracy.

This process was developed in England during World War II to make steel castings with extremely accurate dimensions and fine as-cast surface finish for aircraft and jet engines. In brief, the Shaw process involves the making of a disposable mold—usually cope and drag—by pouring a refractory slurry over an accurate wood or metal pattern. After slurry has set but still has some elasticity, the pattern is drawn. Mold halves are fired at 2000 F and permitted to cool to any desired temperature for pouring.

Pattern Shop

Since the final casting can be no more accurate than the original pattern, a precision pattern shop is the first basic ingredient to success in the Shaw proc-

Fig. 1 . . . Flask boards are locked around pattern.

Fig. 2 . . . Ceramic slurry is carefully poured.

Fig. 3 . . . Flask is removed from hardened mold.

Fig. 4 . . . Pattern is stripped with back-off screws.

Fig. 5 . . . Here's the mold with pattern removed.

Fig. 6 . . . Mold is moved to firing rack and ignited.

Fig. 7 . . . Volatile agent burns off mold.

Fig. 8 . . . The baked copes and drags are cemented.

Fig. 9 . . . Group of molds are ready for pouring.

Fig. 10 . . . Casting looks like this after shakeout.

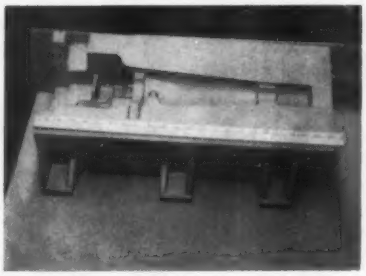


Fig. 11 . . . Here is one half of cast core box.

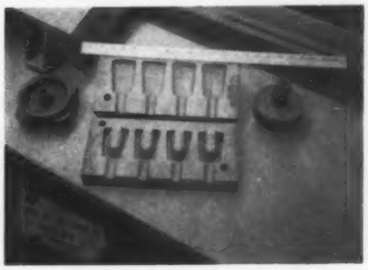


Fig. 12 . . . Both halves of another shell core box.

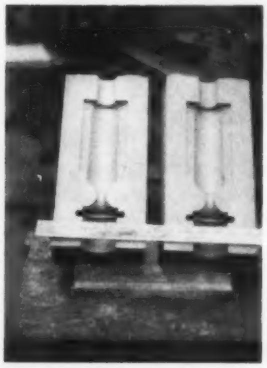


Fig. 13 . . . Cast-to-size die casting dies.

Fig. 14 . . . Die-casting dies are cast in H-13 steel.

ess. Sarcol has a fully equipped pattern shop with craftsmen capable of working in the realm of ± .001 in. The closely integrated precision production team numbers a total of 30 specialists in the whole shop.

Probably the best way to get a full appreciation of our process is to walk through the shop and observe the various operations. The pattern shop builds experience into each job. Thorough familiarity with shrinkage characteristics of mold and metal are a must to achieve the dimensions that the die caster wants in his final casting. Patterns must be made with care as any flaw in the pattern will be reproduced exactly in the finished casting. Wood patterns are usually finished with a coat of wax as varnish may react adversely when in contact with some of the chemicals used in this process. The pattern and gating is mounted on a flat board or metal plate.

A mounted precision wood pattern of a shell core box is being readied for molding in Fig. 1. An adjustable slurry box is fitted around the pattern board for each job. You can see four plywood flask boards locked in position with clamps in Fig. 1. The pattern is now ready to be invested in a ceramic slurry.

The slurry for each mold-half is made as an individual batch since it sets solid quickly after mixing. A carefully weighed quantity of powdered refractory material is mixed with a liquid binder of ethyl silicate in much the same way that you mix a milk shake. A catalytic agent is added that controls the gelling time of the mixture. The slurry is carefully poured over the model in Fig. 2. Slight agitation is sometimes required to avoid air pockets in the mold. After setting for a few minutes the slurry attains a solid but pliable elastic state.

Then clamps are removed and sides of flask drawn away, revealing the drag mold. Now refractory mold looks like Fig. 3 Mold is rolled over and pattern gently drawn from mold. In Fig. 4 this stripping operation is being accomplished with the aid of back-off screws.

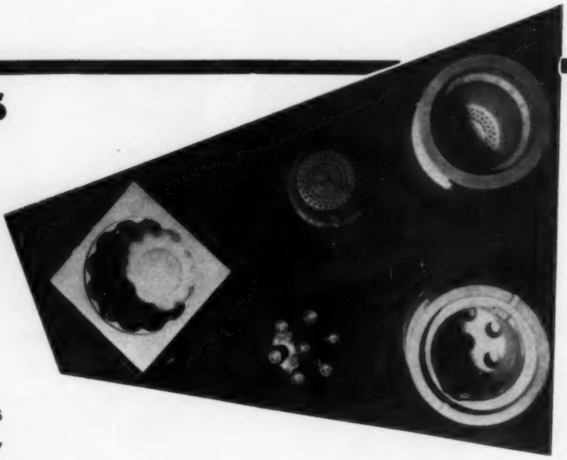
Extreme care is required in this operation as excessive tension could rupture the gel at points of stress concentration. After stripping, complete elastic recovery occurs so there is no change in size or loss of detail. At this stage, the mold is flexible enough and also strong enough to be stripped from a model with no draft, or in some cases one with moderate undercuts.

When stripping is completed the mold is inspected again (Fig. 5). If approved, the mold is carefully moved to a firing rack (Fig. 6). The mold is then ignited to burn off all volatile surface agents (Fig. 7). After burn-off is completed the mold is ready for the bake oven. Baking is done for eight hours at 2000 F.

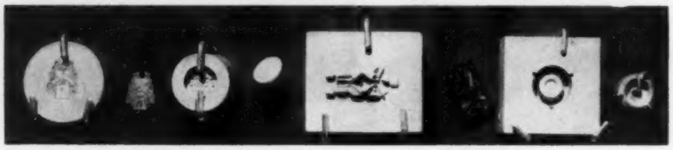
During the baking cycle the gelled binder burns out of the mold, leaving minute silica particles between the larger particles of refractory material. This produces a fine micro-crazing throughout the structure of the mold. Under magnification the network would resemble a pile of ragged baseballs separated by, yet bonded by, grains of fine beach sand. This structure permits each granule of refractory material

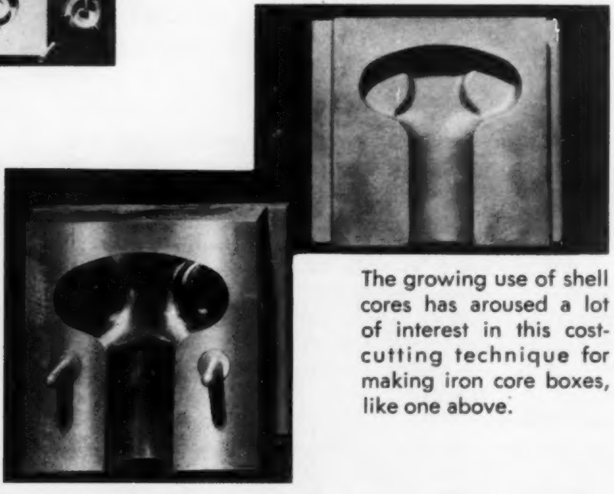
show case of shaw process castings

At the 1959 AFS Engineered Castings Show in Chicago, a large number of cast-to-size patterns, molds and dies were on exhibit. A few of them are pictured on this page. To the right are three dies and two parts made from them.



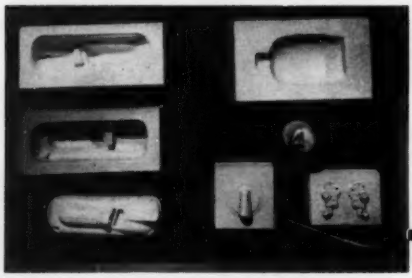
The line-up below displays four Shaw Process castings and the parts made therefrom. Starting from the left, the first is an embossing die cast of 0-6 tool steel; next is an injection mold of 0-1 tool steel; next is a plastic compression mold (core); and on the right is a zinc die casting die made of H-13 tool steel.





The growing use of shell cores has aroused a lot of interest in this cost-cutting technique for making iron core boxes, like one above.

The plastic toy industry needs lots of slick shapes to satisfy the changing whims of children. Below are a few examples of how cast-to-size dies meet these demands.



to be separated from the next by a micro-crack.

The final refractory mold is made up of an interlocking mass of small silica-bonded refractory granules divided by craze-cracks so small that they do not impair the surface finish of the casting produced in the mold. These cracks provide permeability.

Molds are permitted to cool down to any temperature after baking. However, before pouring, they are usually preheated to at least 300 F to eliminate risk of any condensed moisture being present.

Cope mold half usually contains gates and risers and is made in exactly the same manner as the drag half just described. After careful inspection, the baked copes and drags are cemented together (Fig. 8). The completed molds are now ready to receive molten metal (Fig. 9).

Pouring the Casting

Practically any metal that can be cast can be poured into these refractory molds. At Sarcol most of our work is either cast in high-test gray iron for shell patterns, shell core boxes and permanent molds; or in SAE H-13 steel for dies used in aluminum and zinc die casting; or in SAE-01 for dies used in plastic molding, metal shearing and metal stamping.

A 200-lb indirect electric-arc furnace provides molten metal for pouring. Metal chemistry and temperature are kept under precise controls because of the ultimate high quality goals that must be achieved. When molten steel at close to 2900 F is poured into the ceramic mold, the mold retains its original dimensions because the refractory material expands into the network of tiny cracks running throughout.

Castings are always cooled slowly in the mold overnight to achieve self-stress-annealing for maximum dimensional stability. When shaken out of mold next day a typical casting has the appearance shown in Fig. 10. Castings are then sand- or vapor-blasted, annealed if necessary, gates and risers removed, and shipped to customer.

Finished Castings

Pictured in Fig. 11 is a finished 150-lb shell core box. Another shell core box, made in high test gray iron, appears in Fig. 12. Die casting dies, cast-to-size in H-13 steel, are illustrated in Fig. 13-14.

Sarcol has perfected the Shaw process to the point where relatively large parts are cast to tolerances rivaling investment castings. As-cast tolerances between castings in consecutive duplication are:

±0.0025 in./in. for sizes 1-8 in.

±0.0020 in./in. for sizes 8-16 in.

Castings have an as-cast finish of 60-80 microinches. Mold life on iron permanent molds for casting aluminum has been improved at least 25 per cent and delivery times shortened as much as 60 per cent compared with machined molds. Cost savings often reach 50 per cent. Similar benefits have been realized in cast-to-size molds for zinc and aluminum die castings and for plastic injection.

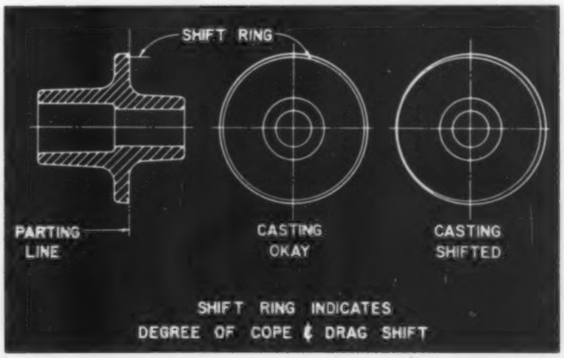
The mastery of this new foundry process has permitted Sarcol to add a new dimension to metalcasting technology, thereby opening the door for production and jobbing foundries to produce better castings more economically. ■ ■ ■

HERE'S HOW

Here's How . . . metalcastings are doing a better job . . . foundries are solving production problems . . . new products are resolving in-plant headaches. If you have an appropriate contribution for this department, send it to the Editor of Modern Castings.

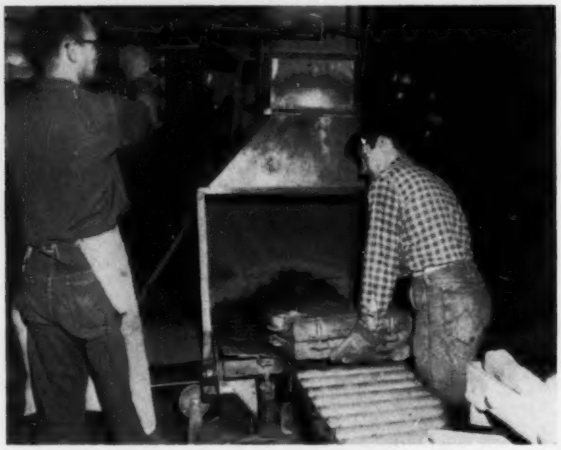
. . . you can use a simple technique for spotting a mold shift between cope and drag. One good trick observed in a plant of the Central Foundry Div., GMC, is illustrated in this sketch.

Castings are designed so a mold shift can be quickly spotted when the casting is inspected after shakeout. By cutting a small groove around the periphery of a symmetrical section one can easily see if the cope and drag were perfectly aligned throughout the casting process. Picture shows how this groove looks with and without a shift. Groove would naturally be cut into the pattern on a noncritical surface. Of course this system doesn't warn you of the shift until after the casting is made but it does let you spot trouble quickly.



. . . Wolverine Brass Works, Grand Rapids, Mich., uses a mobile shakeout hood to serve a multitude of roller conveyor lines leading from molding stations. As soon as poured molds are ready to shakeout, the portable hood is manually rolled on dual track until opposite one of the

roller conveyor lines. Molds are dumped on shakeout grid. Sand falls through onto shakeout belt which hood straddles. Sand travels away on belt; helper hangs castings on overhead chain conveyor; and dust travels up through hood, out into exhaust system.



. . . Hamilton Foundry, Inc., Hamilton, Ohio, stretches their flasks when they find out they're not deep enough for that new job. Instead of buying new flasks they solve the problem by bolting strips of wood to flanges around edge of flask. Picture shows a mold set-up with several inches of flask depth gained from wood strips on top and bottom of cope and about four inches added to bottom of drag. Jobbing foundries have to be ingenious with economies like this to stay competitive on small orders.

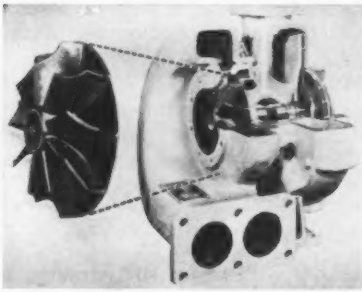
. . . The Markey Bronze Bushing Co., Delta, Ohio, uses a Hough Payloader tractor shovel to move 18 tons of molding sand during an 8-hr day from storage to conveyors and hoppers for eight molding stations. Tractor also handles about four tons of cast bronze bushings and bearings per day, transports machinery and helps with general plant maintenance.

. . . Minneapolis Electric Steel Castings Co., Minneapolis, unloads bulk sand from boxcars. Scoop is guided by man but power is supplied via a steel cable and pulley attached to a power supply such as a winch or power take-off. Sand spills out door into tote box which is carried away by truck.

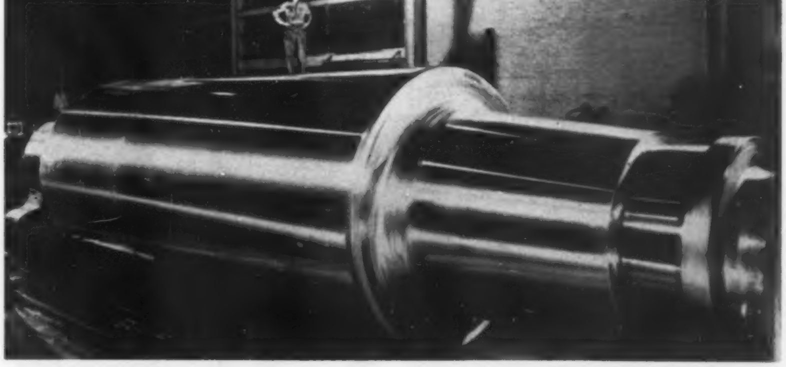
. . . Albion Malleable Iron Co., Albion, Mich., has engineered and produced the nation's first artillery projectiles from malleable iron. Picture shows automated shell core machine producing 81 mm cores . . . control panel on left . . . gas heated core box in center . . . finished cores on right. Frank B. Rote, Technical Director of Albion, is shown examining an assembled 81 mm shell. Production includes anti-personnel shells for mortars and howitzers and components for atomic weapons and small missiles.

. . . The National Supply Co., Torrance, Calif., uses a mobile ultrasonic reflectoscope to inspect large castings in the yard. Equipment is mounted on a motor scooter so it can be brought quickly to the castings. Saves time and wear on heavy duty moving equipment.

. . . Haynes Stellite Co., New York, mass produces de-icer vanes for an air duct system. Vanes are investment cast with several transverse channels that lead back to the trailing edge. Heated air at 600 F keeps ice from forming around the first stage of a compressor.



. . . Mackintosh-Hemphill Div., E. W. Bliss Co., Midland, Pa., sets size records for cast rolling mill rolls. This 110,000-lb. alloy steel back-up roll will be used on a 130-in. plate mill by Armco Steel Corp.



3 BIG 'M's Modernization Mechanization Maintenance

by Vernon E. Lich
General Steel Castings Corp.
Granite City, Ill.

With labor costs rising every year our high labor content foundry industry can only hold costs down and production up by resorting to more mechanization. And materials handling is an area where mechanization is needed most. Somehow we must get our industry out of the sand and up on wheels.

Along with modern materials handling, maintenance must go hand-in-hand. In the good old days of wheelbarrow and shovel, breakdowns were virtual nonexistent. Today's story is quite different; materials-handling equipment plus preventive maintenance is the lifeline of any foundry. Production scheduling and ability to produce depend on the condition of machines and ability to avoid down time.

At the Granite City plant of General Steel Castings Corp. we feel that mechanization and maintenance must work together. Every effort is made to keep these two elements in balance when improvements and additions are made in the foundry.

Here are six case-history examples which demonstrate materials handling and maintenance improvements made at the Granite City Plant in the past few years.

Modernize with pneumatic handling additives

A system for pneumatic handling of silica flour, bentonite and corn flour from railroad cars to silo storage and then to sand mills is an integral part of our materials handling facliities. These sand additives were formerly packaged in bags and shipped in box cars. The cars were unloaded by a crew of men using a hoist, several dollies plus plenty of lifting and resting. The cost of unloading a ton of silica flour was \$3.10, bentonite \$4.08 and cereal \$4.68. After installation of the new system, unloading costs were reduced to \$0.35 per ton for silica flour, \$0.36 for bentonite and \$1.10 for corn flour. An additional saving of \$2.75 to \$4.40 per ton was made through bulk purchases, eliminating the bagging charges. Total savings are calculated to be \$350 to \$400 per carload.

Our outside silo storage tanks are shown in Fig. 1. Each tank holds approximately two carloads and is connected to the pumps in such a way that the materials cannot be mixed. Running transversely to the railroad tracks and under the center row of bins, a tunnel houses two pumps as shown in Fig. 2 and 3.

The pump is mounted on wheels and can be connected to any one of five stations. So it can be used to unload cars and blow to storage or remove from storage and blow to the sand mills. The material flows by gravity from the large overhead silos into the pumps. Pump uses a 60-hp motor and 20-psi air pressure to compact the material and force it into an air chamber where it is aerated and blown through a 6-in. or 4-in. pipe to its destination.

At the sand mills the material is blown into a bin and the air is removed through a bag-type dust collector. Switch valves are provided so that any

Fig. 1 . . . Outside silo tanks.

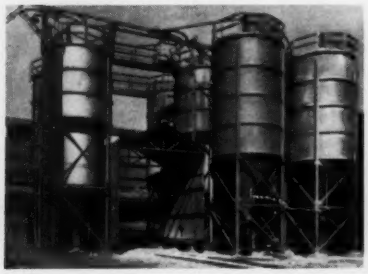


Fig. 2 . . . Tunnel houses pumps.

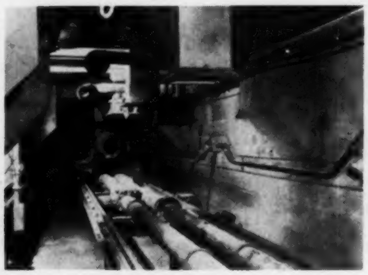
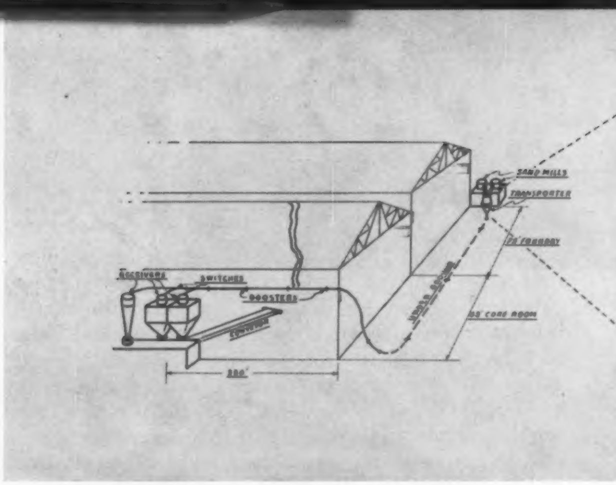


Fig. 3 . . . Pump blows additives.



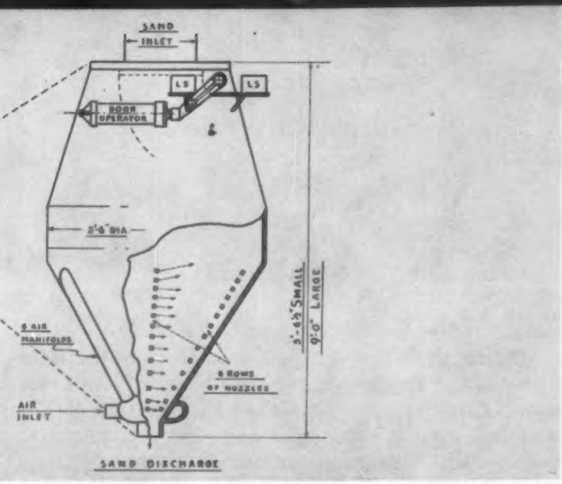


Fig. 4 . . . Core sand pneumatically conveyed from sand mills to coreroom over this path.

Fig. 5 . . . In the transporter sand is given whirling action by air and fed into pipe at bottom.

number of bins can be serviced. Each airtight bin has a high-low bin signal to indicate the level.

Bag disposal, easy one-man unloading, no bagging charge, outside storage, all add up to advantages of bulk handling sand additives in this manner.

Modernize . . . with pneumatic sand conveying

You are all familiar with the standard methods of moving sand—belt conveyors, pan conveyors, elevators, vibrators and others. The installation of such equipment, if incorporated in the original foundry design, presents a problem which can easily be met by spacing sand-using and handling equipment properly and designing buildings to suit.

When it becomes necessary to install belts, elevators and other equipment in existing buildings with overhead cranes and other large space-using facilities, the problem quickly changes. Major structural changes might be necessary if the conveyor is to go overhead or expensive tunnels might be installed in order to place the conveyor under the floor. Usually such installations must be made with no, or at least a minimum of, interference with plant operations.

Even after a conveyor system is installed and operating, it is at the very best a rigid installation. Even minor changes in direction or rerouting material flow can require costly alterations.

In recent years, pneumatic systems have been developed to handle material through a pipe. Much has been done to handle dry, fluffy material that can be mixed with air and handled as a liquid; but molding sand, mixed and ready for a mold or core, has long presented a tough delivery problem.

A pneumatic system has now been developed to transport tempered mold and core sand through a pipe. The sand is introduced into the pipe by a whirling action within a transporter.

Further whirl is imparted by air jets spaced about 100 ft apart in the pipe.

In 1957 the Granite City Plant installed a pneumatic batch-type conveyor handling 40 cu ft, or two tons per batch.

Besides the 40-cu ft transporter, the installation uses 140 ft of 4-in. underground pipe, 350 ft of overhead pipe, two switches and three receivers as shown schematically in Fig. 4. This system conveys core sand from the sand mills to two hoppers in the core-

Fig. 6 . . . Boosters aid sand flow.

Fig. 7 . . . Switches control delivery.

Fig. 8 . . . Pipe bends are reinforced.


Fig. 9 . . . Big savings come from handling bricks in pallets.

room that feed six core blowers.

The length of time to blow a batch from the transporter to the hoppers at the core blowers varies from two to three minutes. Air is used at the rate of 1 cu ft of free air for 5 lb of material conveyed. Approximately 30 to 40 tons of sand can be moved per hour.

The operation of the system is completely pushbutton by a sand-mill operator. The batch of sand is gravity fed through an open door in the top of the transporter. A button is pushed by the mill operator; the transporter door closes and in so doing actuates a limit switch to open a solenoid valve to introduce air to the transporter and conveyor line.

In the transporter, shown schematically in Fig. 5, the sand is given a whirling action by the air and fed into the 4-in. pipe at the bottom of the transporter. Within the pipe at strategic locations the sand is kept in whirling motion by additional air introduced by "boosters," Fig. 6.

The sand is discharged from the pipe into a circular receiver located over a hopper. Sand falls to the bottom of hopper and air escapes through the opening vents in the top.

Bin signals at the core blower location indicate on the control panel the need for sand. The mill operator, by use of buttons, Fig. 7, sets the switches to convey the sand to the proper hopper.

Maintenance requirements have been small considering the amount of sand put through the system. The pipe bends near the end of the system receive the most wear. Shown in Fig. 8 is a specially designed reinforced bend which gives satisfactory service.

Depending on the type of sand conveyed, some kind of cleaning must be done to the pipe. A release agent, soapy water or chains may be used. Chains blown through the pipes do a good cleaning job and minimize plug-ups.

Mechanize . . . with lift trucks

In any foundry, handling materials can be a substantial part of the casting cost. Mechanical aids purchased for materials handling is capital well invested for cost improvement.

In the lift-truck field, tremendous advances have been made in the last ten years. One can buy attachments to fit a lift truck to handle almost any material or package—from plowing snow to unloading a gondola car.

General Steel tries to purchase everything palletized. Ferro-chrome, welding rod or brick, all are palletized for low-cost handling. In 1950 open-hearth brick of many sizes and shapes arrived packed loose in a box car. A crew of ten men unloaded the car and stacked the brick in various storages for an average of $21.00 per 1000. Today, with the use of a two-ton lift truck and an elevator which connects our charging floor storage and the checker floor storage, bricks are unloaded for $0.70 per 1000, for a savings of $200 per car. This savings will be doubled by the time the bricks get to the job as shown in Fig. 9.

In Fig. 10 a lift truck is shown with a hopper box and a front discharge gate for pouring concrete. Prior to this innovation, concrete was handled by wheelbarrows. Six to twelve men with wheelbarrows were required, depending on the distance involved. Today two lift trucks can be equipped with one-half yard boxes and can easily keep two ready-mix trucks going without wasting time.

Many times it is necessary to unload a box car where dock facilities are not available. A lift truck is shown in Fig. 11 entering a car using a portable magnesium ramp. Ramp is easily towed from car to car and can hold a loaded two-ton truck.

For transportation of cores, lift trucks are modified as shown in Fig. 12. You will note that the usual lift forks are removed, the counterweight radiator guard has been placed in the front, and a small 12-in. lift platform has been placed in the rear. This lift platform enables the operator to pick up the front of the core carrying trucks for easy towing on the two rear wheels. In coremaking operation, 900 core carrying trucks and six lift trucks are used for handling.

Mechanize . . . with power conveying

Our metalcasting work requires large flasks and cores, so power must be applied to conveyors.

In Fig. 13 you see a 42x96-in. flask having a weight of 6000 lb when loaded with sand. The flask has 1-in.x1-in. steel runners welded to the grid bottom to provide a suitable surface for contacting the rollers on which it travels from roll-over unit to finishing station. A specially designed hook has one end placed over the flask trunnion and the other attached to a chain link drive. Movement of the flask is then con-

Fig. 10 . . . Truck moves concrete.

Fig. 11 . . . Portable truck ramp.

Fig. 12 . . . Lift truck pulls cores.

Fig. 13 . . . Powered flask mover.

Fig. 14 . . . Limit switch stops flask.

Fig. 15 . . . Grabs keep flask level.

trolled by push button. Usually, after the hookup is made, the finisher performs his work as the flask moves along the conveyor. When the flask hits the end limit switch, the drag chain stops and the flask is ready to be lifted to the closing floor (Fig. 14).

The drag chain in all installations has a secondary purpose in dragging back the refuse and spillage sand on the return flight. Return flight is located in a sloped recess so that spillage and sweepings will automatically be returned to sand system (Fig. 14). Thus the chain conveys the flask and cleans the floor in one operation.

To make the small molding floor independent of the overhead crane, special hoists and man-saver grabs were installed on monorails to place flasks and change patterns. The grab is shown in Fig. 15. This grab is controlled by two sets of cables on a common drum and therefore will not rotate or tip; the flask will always stay level regardless of where it has been clamped. It's easy for one man to pick up a flask from storage pile and place it over a pattern for slinging. The grab itself is power operated in opening and closing under the upper flange of the flasks. A six-button pendant permits the operator to open or close the grab arms, raise or lower the grab and move the hoist back and forth.

Maintenance... of rubber conveyor belts

At the Granite City plant of General Steel Castings Corp. there are 50 different conveyor belts with 12,000 ft of belting, ranging from 18 in. to 42 in. wide. The sand system is in the center of our 1975-ft long foundry. All molding and some core sand travel on rubber conveyor belts. Likewise, the majority of the refuse sand returns to the central system on rubber belts. With this amount of conveyor equipment, it behooves us to carefully follow a consistent program of proper design and maintenance.

Present-day belt costs range from $5.00 per ft for 18 in., to $13.00 per ft for 40-in. belt. On one of the longer conveyors, it takes just four minutes to completely rip a $10,000 belt! So everything possible must be done to prevent accidents. Foundry conveyor belts have the habit of tearing and ripping rather than actually wearing out. However, if you provide the proper structural design, furnish the correct type of belt, and vulcanize the splice, the yearly maintenance costs can be held to a minimum.

The type of belt used wherever possible is 5-ply with 1/4-in. rubber top, 1/8-in. bottom, and cross wires inserted every 36 in. This type belt should be used where there is a possibility of a rod or riser ripping the belt. If some metal object should pierce the belt and start a rip, the cut would progress only 36 in. Then the cross wires would eject the object or stall the belt if the object remained in place. This belt type with cross wires sacrifices three to six feet of belt but saves the remaining 500 to 1000 ft.

The vulcanized splice is the next step in conveyor-belt improvement. Vulcanizing will make the belt endless and provide a smooth surface for strike-offs and scrapers to slide over. Most of our tears in the past resulted from loose clamps or splice fasteners which pulled out and started a longitudinal rip in the belt. To guard belts for long life, all splices, small holes and tears must be vulcanized. Prior to vulcanizing, our long belts had as many as four or five mechanical splices with short pieces of belting "jumped in" to repair rips. These mechanical splices presented ideal locations for foreign objects to catch and damage the belt. Also the clamps were subject to leakage of fine material as they rattled over the idlers and pulleys. Vulcanizing has eliminated this situation.

Vulcanizing is a simple procedure, once your personnel are trained. Our maintenance men were trained by a service man hired from the local belt distributor. Since then we have made approximately 75 vulcanized splices and numerous hole repairs without a single failure.

Figures 16-19 show workmen splicing two short pieces of belt together. Normally this job would be done on some walkway or down in a tunnel but for

Fig. 16 . . . Stripping belt fabric.

Fig. 17 . . . Each ply is stripped.

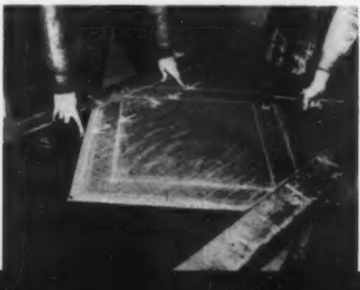


Fig. 18 . . . Ends are spliced.

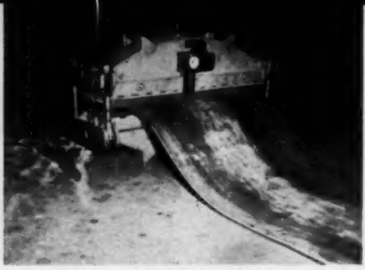


Fig. 19 . . . Splice is vulcanized.

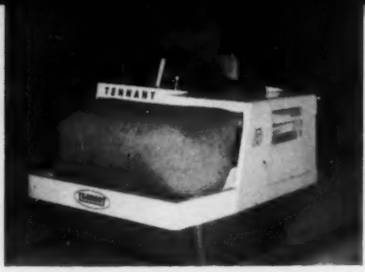


Fig. 20 . . . Floors are kept clean.

this demonstration the work was done in the storeroom.

The first step in vulcanizing is to lay out the pattern of the splice using a "T" square and rule for accuracy. After cutting through the first ply, the fabric is stripped back as shown in Fig. 16. Then each ply is cut and stripped until the pattern looks like Fig. 17. The ply fabric is scraped and severly wire-brushed to insure proper adhesion of the fibers with the vulcanizing rubber.

The opposite side of the other end of the belt is likewise processed in the same manner. When the ends are brought together, they fit perfectly into a diamond-shaped stepped splice as shown in Fig. 18. The ends are carefully matched and the two separate ends clamped to the large cutting boards. Splice lap is double checked to see that each step sets flat. Both top and bottom splices are coated with vulcanizing gum rubber and at the right moment pressed together. The splice is then ready for the application of pressure and heat by the vulcanizer (Fig. 19). The vulcanizer pads cover about 12 in. of belt so at least five heats must be made on a 30-in. belt. This type splice takes approximately five extra feet of belt for a 30-in. wide conveyor.

Vulcanized splices, together with cross-wire belting, keep our belting running longer with a minimum of maintenance.

Maintenance . . . for good housekeeping

Our plant is well known for its good housekeeping —each day the foundry floor is swept and refuse systematically collected. Two pieces of equipment, a self-propelled vacuum sweeper and a special dump truck handle the job.

We are now using our sixth floor sweeper, shown in Fig. 20. Foundry and coreroom can be kept looking neat and clean by running the sweeper eight hours per day. Sweeper is gas-powered, has a 42-in. brush, and will collect and carry approximately 200 lb of refuse on each trip. It can run over a refuse box and the collected refuse hydraulically discharged.

A dust collector is an integral part of the sweeper. About ten years ago, five or six men with push brooms did the cleanup job. Now one man with a power sweeper can do the work better.

For collecting refuse, the tote and dump equipment shown in Fig. 21 is used. The same special container is used for collecting the refuse and hauling it to the dump. The old method of collecting scrap and debris required three dump trucks with two men on each truck. The new tote-dump system has replaced two of these trucks and covers much more of the plant than the dump trucks.

There are 38 containers throughout the plant for collecting rubbish, scrap lumber, punchings, sweepings, foundry scrap, etc. Figure 21 shows our most popular container on the truck in transporting position. The dump unit is located on a 2-1/2-ton truck. It is controlled by three hydraulic levers located in the cab. The unit can lift the box from the ground, place it in transporting position, then dump the container and return it to the regular location.

The lifting power gives it a maximum lifting capacity of 7500 lb. The containers vary from 1-1/2 to 12 cubic yards, depending on the type of refuse to be handled—paper or scrap, etc. The windproof storeroom container for loose paper can be seen in Fig. 23 on the truck, in dumping position.

This debris-handling method permits one-time loading and eliminates rehandling. Instead of accumulating refuse on the floor in piles, which is unsightly and requires additional manpower to clean up, neat-looking containers are located at the source for direct loading.

■ These are but a few of the many case-history examples of how better foundry operations have depended on modernization, mechanization and maintenance. ■ ■ ■

Fig. 21 . . . Toting refuse box.

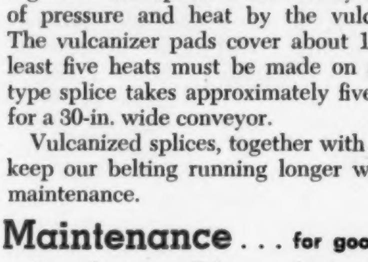


Fig. 22 . . . Dumping refuse box.

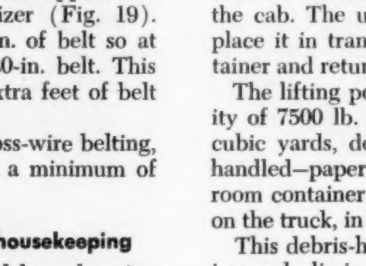
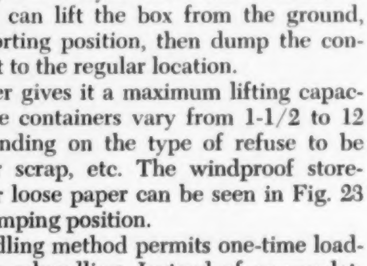


Fig. 23 . . . Special box with lid.



GREEN SAND PRINCIPLES FOR CONTROLLING QUALITY

1 clay-sand-water

2 additives (coming in May issue)

3 molding

4 casting defects

Modern Castings presents here the first of four installments of the official 1959 exchange paper from the American Foundrymen's Society to the Australian branch of the Institute of British Foundrymen

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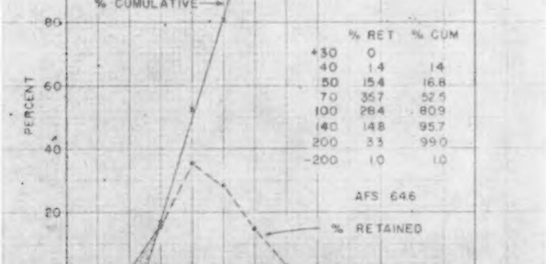
Knowledge and thorough application of the principles governing the properties and behavior of green molding sand are needed to control casting quality. The principles discussed in this exchange paper refer entirely to synthetic molding sands used in iron foundries. Their application to non-ferrous and steel foundry sands will be mentioned where applicable. The information presented is taken mainly from researches and foundry experiences of the authors, both published and unpublished.

A synthetic green molding sand should be viewed as an aggregate composed of silica particles, clay, water and special additives. The bulk of the aggregate is supplied by the silica particles in the base sand.

The *base sand* may be a clay-free, washed, white silica sand or a less pure, tan-colored sand containing some small percentage of clay. Aside from considerations of purity and clay content, the average fineness number and particle size distribution are most important. To illustrate, consider the sieve analysis of a typical silica sand reported in Fig. 1 (according to the standard methods of sieve analysis of the AFS)[1].

Fig. 1 . . . The sieve analyses of a base sand may be plotted as per cent retained on each sieve or cumulative per cent retained on successive sieves.



The average fineness number, calculated from the sieve analysis, is in this case 64.6. The sieve analysis is graphically presented either as the percentage retained on each sieve or as cumulative percentage retained on successive sieves (Fig. 1).

Bulk, Coarse and Fine Fractions

Three major fractions of the sieve analysis are identified as: the *bulk*, the *coarse* and the *fine fractions*. The *bulk fraction* is that percentage of sand grains represented by the middle portion of the curves, Fig. 1. The sand may be defined by the number of screens over which the bulk fraction is spread as a 2, 3, 4, 5, etc. screen sand (or a 2, 3, 4, 5, etc. sieve sand). A screen fraction is arbitrarily defined as one with more than 10 per cent retained on that screen. Thus, a four screen sand is one where the bulk of the sand is retained on four adjacent screens with each retaining more than 10 per cent. The sieve analysis in Fig. 1 is an example of a four-screen sand. The bulk fraction provides the bulk of the molding sand and normally comprises more than 80 per cent of the aggregate by weight. The number of screens over which the bulk fraction is spread may vary in different sands. Present experience favors the four-screen type of distribution for synthetic molding sands[2].

Optimum sieve analysis may be achieved by mining and blending sands from the same pit to the desired distribution or by blending sands from different pits. For example, Table 1 lists screen analy-

TABLE 1—SIEVE ANALYSIS OF TYPICAL LAKE AND BANK SANDS* AND A BLEND OF BOTH

U. S. Sieve	Percent Retained		
No.	Lake Sand	Bank Sand	60% Lake 40% Bank
20	0.13	0.00	0.08
30	0.67	0.02	0.41
40	2.35	0.06	1.43
50	16.02	1.48	10.20
70	45.82	13.30	32.81
100	33.28	43.27	37.28
140	1.23	27.66	11.80
200	0.10	10.90	4.42
270	0.01	1.89	0.76
Pan	0.39	1.42	0.80
AFS No.	56	88.1	68.7

* These are sands which are mined mainly in the Great Lakes region of the U.S.A.

sis for a three-screen AFS No. 56 Lake sand and an AFS No. 88.1 four-screen bank sand. Also shown is a 60/40 blend to achieve an AFS No. 68.7 four-screen distribution. While three-, five- and six-screen bulk fraction sands can be used, the four-screen type seems to be most versatile over a wide range of conditions.

The *coarse fraction* of the sieve analysis comprises the total percentage of sand grains retained on the screens coarser than those of the bulk fraction and in amounts less than 10 per cent. The total coarse fraction must be limited in amount, usually to less than four per cent for a four-screen sand. This limitation is necessary since an excess of coarse particles contributes to poor casting surface finish. Also, coarse particles are easily dislodged from the mold cavity surface and become dirt in the casting. In the case of a typical 60-70 AFS sand of the four-screen type, the coarse fraction occurs on the No. 40 or coarser sieve and must be limited to less than 4 per cent. In a finer sand, the coarse fraction might remain on the No. 50 or 70 screens.

The *fine fraction* of the sieve analysis includes the total percentage of sand grains retained on screens finer than those of the bulk fraction and in amounts of less than 10 per cent. The total fine fraction must also be limited in amount, usually to less than about 5 per cent for a sand of the four-screen type. This limitation is necessary since an excess of fine particles causes balling to occur during mulling. When water is added, the fines and clay agglomerate to form balls during mulling. This balling prevents the clay from being thoroughly disseminated throughout the mass. Furthermore, the balls containing about 15 per cent water are potential sources of pinholes or other gas defects. While the percentage of fines must be limited to a maximum percentage, a minimum percentage is also desired.

The proper percentage of fines is required during mulling to form agglomerates which contain a uniform distribution of sand particle sizes, clay, water and special additives. Two to three per cent of total fines on the No. 200, 270 and pan are a required minimum for this purpose for a typical four-screen 60-70 AFS sand. In the absence of the fines, clay balling can also occur. The ability to properly mull the sand and disseminate the ingredients requires this proper balance of coarse, bulk, and fine sand particles in the base sand.

Clay-sand-water Proportions

Proportions of clay, sand and water in the aggregate largely determine the properties which can be developed by green molding sands.

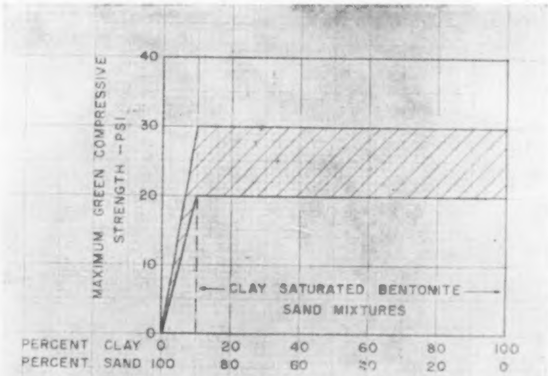
Clay: Green sands may be considered as clay-saturated or unsaturated aggregates according to the clay percentage present. A clay-saturated green sand is defined as one containing enough clay so that any further increase in clay content will not cause an increase in maximum green compressive strength of the aggregate. This definition is portrayed graphically in the schematic diagram of Fig. 2 from data of reference 3. The abscissa in Fig. 2 refers to the per cent of clay in the clay-sand mixture on the dry basis. The ordinate refers to the *maximum* green compressive strength developed when increasing percentages of water are added to the dry mixture. The moisture percentage which develops maximum green compressive strength can be calculated by a method described in a later section.

Figure 2 demonstrates that a clay-saturated sand has about the same compressive strength as the clay by itself, i.e. the mixture is fully bonded. The shaded area on Fig. 2 is the variation in maximum strength of the clay-sand mixture due to clay purity and source and sieve analysis of the base sand.

The specific percentage of clay required for saturation depends on purity and type of clay, base sand and additives. However, in most cases about 8 to 12 per cent of bentonites (either sodium or calcium bentonites) or about 20 to 25 per cent fire clay is sufficient to produce a clay saturated mixture. Below the saturation percentage, increasing clay content produces an increase in green strength properties.[3,4,5,6] At and above the saturation percentage, green strength properties are no longer sensitive to clay content. Green properties are of course affected by the moisture content of the aggregate. The foregoing discussion refers to mixtures containing sufficient water to develop maximum strength. The effect of moisture percentage variation will be considered later.

With reference to clay content there are three major types of synthetic sand practices. ***First, the clay-saturated sands may be considered.*** These mixtures contain a percentage of bentonite type clay corresponding to the saturation point, i.e. 8-12 per cent*. By AFS clay analysis, the percentage of AFS clay will commonly run from 9 to 14 per cent, or true clay particles of about 8 to 12 per cent (see reference 7 for true clay analysis). The clay-saturated type of sand is presently widely used in iron foundries and in foundries producing the heavier non-ferrous alloys. Clay-saturated sands are probably the most versatile green sand mixtures for a wide range of casting

Fig. 2 . . . When a clay-sand mixture becomes saturated with bentonite it reaches a maximum green compressive strength equal to the strength of the clay by itself. The spread of data in the shaded area is attributed to variations in clay purity and base sand.



weight and alloy types. Expansion defects, erosion or cuts and washes are either eliminated or reduced to a negligible percentage attributable to the molding sand itself. Since such sands normally have high strength (14.0 to 20.0 psi green compressive strength), they require adequate ramming to develop their properties (preferably over 85 mold hardness). The requirement of adequate ramming can be a limitation of this type of sand if the foundry does not have suitable molding equipment.

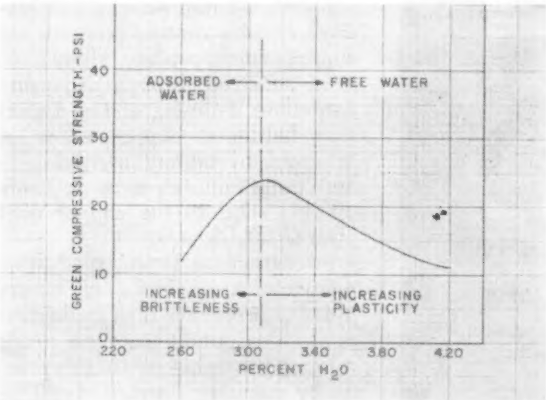
A second type of sand practice involves the use of *clay in amounts which are slightly but definitely less than the saturation percentage*. The amounts actually carried in sand systems are about 6 to 9 per cent AFS clay in bentonite bonded sand or about the equivalent amount of 10 to 15 per cent fireclay. Such sands are used more for lighter castings where expansion defects, erosion or cuts and washes are less of a problem.

A third practice is a *low clay content practice involving about 4 per cent western (sodium) bentonite* and used primarily by steel foundries. Expansion problems are a maximum with this type sand. However, because of its low green strength, 6 to 9 psi, and high moisture content, it can be readily molded.

The effects of clay type on the properties of the aggregate will not be considered because this subject has been covered by other authors. The three major clay types do have well recognized foundry uses. Western bentonites are used in sands requiring a higher level of dry compressive strength—in excess of 80 psi for example. Southern bentonites are used in sands where a lower dry compressive strength is acceptable—40 to 80 psi for example. Fire clay produces moderate dry strength. Maximum dry compressive strengths, over 200 psi, can be obtained with mixtures of fire clay and western bentonite.

*Synthetic molding sands saturated with fire clay are not commonly used. The 20 to 25 per cent fireclay required for saturation produces a sand of low permeability and high moisture requirements.

Fig. 3 . . . The maximum absorbed moisture content is indicated by a peak in green compressive strength. Additional "free water" is needed to develop dry compressive strength and plasticity or deformation. This sand contains 8% western bentonite.



The moisture required to produce the desired properties in a green sand can be calculated according to a method described by the authors in reference 8. The method is based on first computing the total percentage of water adsorbed by all of the sand ingredients. The maximum adsorbed moisture content is associated with the development of maximum or peak green strength properties as illustrated in Fig. 3. Additional water, called "free water," is required to develop dry compressive strength and plasticity or deformation*. The method of computing adsorbed and "free water" is described in reference 8.

The final selection of moisture range is exceedingly important for proper functioning of the sand and involves mainly the use of the proper percentage of free water in relation to the clay content of the sand. There are three important practices followed in using this principle. First, in clay-saturated sands about 10 to 30 per cent free water is used. More than this amount causes a serious loss in flowability and excessive dry strength resulting in shakeout difficulties. Second, in the sands containing slightly less than the clay saturation level, about 30 to 50 per cent free water is used.

This practice is especially popular in shops using a heap sand where drying out actually reduces free moisture to the 10 to 30 per cent free water level by the time it is used. Third, the 4 per cent western bentonite type sands employ 50 to 100 per cent free water in order to enhance dry strength and erosion resistance. In addition, the 10 to 15 per cent fireclay bonded sands require 50 to 100 per cent free water to develop adequate plasticity and dry strength. The practices mentioned above are based on a sound use of the effects of free water on sand properties and are essential in the proper performance of molding sands.

In using the calculation method it should be recognized that the adsorbed requirements of different materials may vary from those cited in reference 8. However, the method described has been used by the authors with no apparent anomalies discovered thus far.

* Deformation is measure of plasticity determined by a testing procedure described in reference 1.

. . . To be continued next month. . . .

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CASTINGS CONGRESS

Preview of Metal Castings Technology

Solutions to foundry problems ranging from a theoretical approach to specific advice to foundry operators will be presented in a five-day roundup of the latest investigations by more than 100 authors at the 64th Castings Congress, May 9-13 at Philadelphia.

Researchers and foundrymen from the United States, Canada and abroad will report their findings to an international audience covering all levels and facets of the industry.

To ensure participation by the most foundrymen possible and to cover problems of specific industry groups, the technical program has been designed to include technical talks, shop courses, symposiums, luncheons and dinners.

Activities of the Gray Iron Division indicate the scope and manner of division participation. Technical sessions for the division start Tuesday with multiple speakers at two afternoon sessions and a shop course at night. A third technical session will be held Wednesday afternoon. On Thursday the division will hold a joint luncheon meeting with the Ductile Iron Division followed by a fourth technical session in the afternoon and a second shop course Thursday night.

One of the best-attended functions of the Castings Congress is the Sand Shop Course, held on opening night. *New Horizons in Sand Practice* is the theme of this year's session. Speakers are:

- C. M. **Eberhardt**, Central Foundry Div., GMC, Danville, Ill., will discuss the green sand molding of crankshafts, emphasizing close tolerances available in green sand.
- Don Rosenblatt, American Foundry & Machine Co., Salt Lake City, chairman of the AFS Steel Division, will discuss the use of air-set binders with an explanation of their applications.
- W. C. Capehart, Plastics Div., Monsanto Chemical Co., Springfield, Mass., will speak on the shell process and its advantages.

A question and answer period will be conducted after the formal presentation with inquiries invited from attending foundrymen.

Co-Chairmen for the meeting will be T. W. Seaton, American Silica Sand Co., Ottawa, Ill., Sand Division Vice-Chairman and Chairman of the division's sand shop course committee; and Larson E. Wile, Lynchburg Foundry Co., Lynchburg, **Va.**

Significant improvements of tensile and stress-rupture properties in copper and copper-base alloys have been achieved through dispersion hardening. Forming of the dispersion hardened copper alloys is achieved by adding molybdenum and tungsten carbide as a finely divided solid to the copper melt prior to solidification.

Strengthening is achieved with relatively small losses in matrix physical properties such as thermal or electrical conductivity.

Learn the techniques of this process by attending *Formation of Dis-*

persions in Molten Copper by Mechanical Mixing by D. N. Williams, J. W. Roberts and R. I. Jaffe.

Can magnesium castings compete with other methods of fabrication in the missiles field? It is possible, says Walter Gronvold in *Short-Time Elevated Temperature Properties of Premium Quality Magnesium Castings,* through premium quality—obtainable by foundry technique and control.

Use of premium quality and the new casting alloys will make magnesium alloys directly competitive with aluminum. The author points out that the responsibility for making this high quality a reality rests with the foundry industry.

Foundries should recognize the quality desired, understand what is meant by minimum guaranteed properties and then demonstrate that it can be done when the new casting designs specify this quality in the cast part.

For an analysis of castings and missiles, attend this thought-provoking technical session.

Fast production of ready-to-use bronze alloy test bars through shell molding appears to have commercial possibilities. In addition to the saving of machining time and other delays and expenses, shell molds would also remove the variabilities of the mold, reduce inclusion of dirt in bars due to crumbling of conventional mold walls and allow molds to be made well in advance of use.

Results of the investigation made by S. Goldspiel, E. W. Chrzan and M. L. Foster, New York Naval Shipyard, Brooklyn, are contained in *Shell-Molded Test Bars for Tin Bronze Casting Alloys.* Attend this technical session to learn of: the correlation of properties obtained with shell compared to core molded bars; the relationship between temperature of pouring and tensile properties; and determination of the effects of such factors as temperature of pour, mold materials, alloy and pattern on the equivalency of results.

High strengths and unusually high elongation under almost all casting conditions were imparted to aluminum alloy A-356 with the application of ultra high pressures during solidification.

High pressures refined the grain size and the eutectic silicon size, increased the silicon concentration of the eutectic and decreased the amount of eutectic present regardless of the casting variable used.

Continued on page 146

TENTATIVE SCHEDULE OF TECHNICAL SESSIONS

64th AFS CASTINGS CONGRESS & FOUNDRY EXPOSITION — May 9-13

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
7:30 am	Authors Breakfast	Authors Breakfast	Authors Breakfast	Authors Breakfast	Authors Breakfast
9:30 to 11:30 am	Light Metals Malleable Pattern Brass & Bronze	Brass & Bronze Pattern Malleable SH&AP T&RI Trustees	Annual Business Meeting & Hoyt Lecture	Steel Ductile Iron Fundamental Papers Die Casting & Perm. Mold	Sand Heat Transfer Ductile Iron Fundamental Papers
12:00 Noon	Malleable Luncheon	Brass & Bronze Lunch. Pattern Luncheon Board of Directors Luncheon & Meeting	Management Lunch. Joint Light Metals & Die Casting R.T. Luncheon	Steel Luncheon Ductile & G. I. Lunch Past Presidents Lunch	
2:00 to 4:00 pm	Pattern Brass & Bronze	Light Metals Education Ind. Engrg. & Cost Gray Iron	Steel Gray Iron Plant & Plant Equipment	Heat Transfer & Fund. Papers Joint Solidification Symposium Die Casting & Perm. Mold Ductile Iron	
4:00 to 5:30 pm	Sand Brass & Bronze Seminar	Sand Light Metals Gray Iron Malleable	Ind. Engrg. & Cost Die Casting & Perm. Mold Sand Steel	Steel Gray Iron Sand	
6:00 pm		Canadian Dinner Sand Dinner	Annual Banquet	Alumni Dinner	
8:00 to 10:00 pm	Sand Shop Courses Mall. Shop Courses	Mall. Shop Course Gray Iron Shop Course		Gray Iron Shop Course Ductile Iron Shop Course	

EXPOSITION

MAY 9-13, 1960

the coming BOOM in foundry purchases

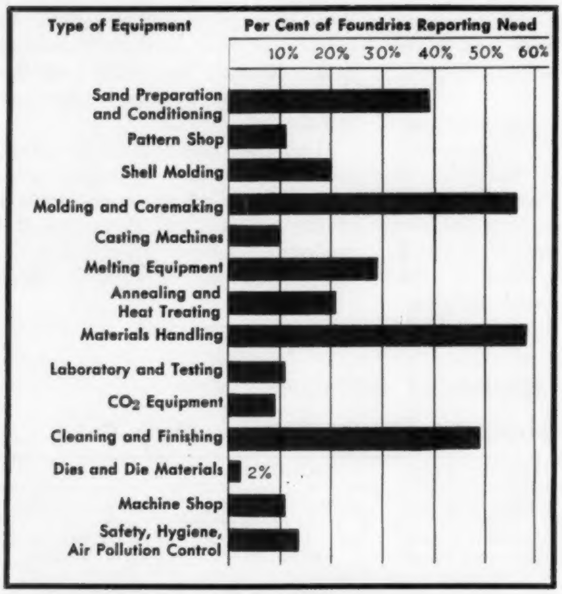
Two booming years in the foundry industry, calling for an average of $18 per ton of capacity, are indicated by a national survey just completed for AFS.

Unparalleled growth in production, matched by giant advances in technology, have been forecast for this decade. The survey indicates that the first two years will justify the title "The Soaring 60s."

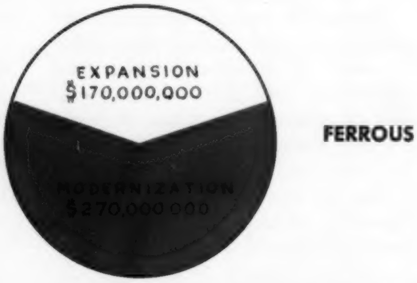
The charts graphically illustrate the indicated production growth, up 15 per cent in 1960 and up 20 per cent in 1961; the estimated outlays for expansion (38%) and modernization (62%); and a detailing of how foundries will spend this money.

Not included in the graphs is a whopping $6,800,000,000 for materials, supplies and special services.

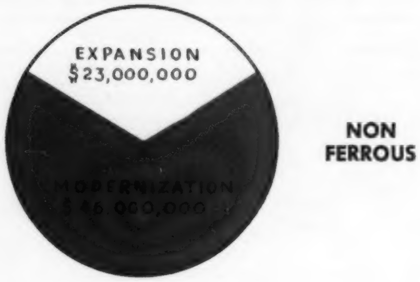
Foundries' huge expenditures on new capital in-

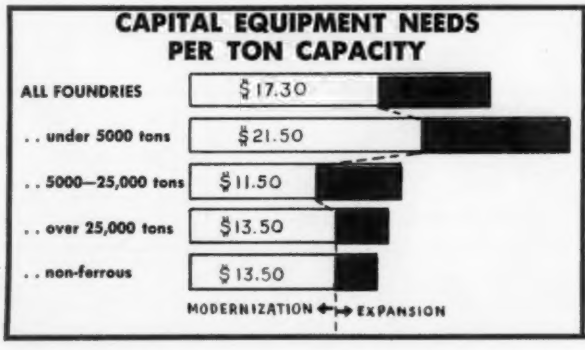


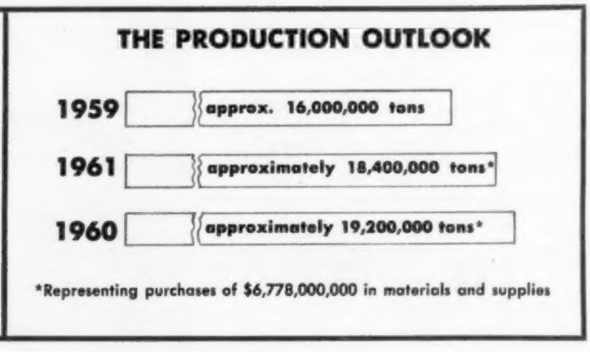
WHERE THE FOUNDRIES SAY THEY WILL NEED NEW EQUIPMENT IN 1960 AND 1961



How $509 million in new equipment would be used.







Exhibitors Product Preview

vestment have been revealed through a survey for the American Foundrymen's Society. During the next two years the average foundry will spend $17.30 per ton of capacity in this category—more than half a billion dollars for the industry.

These foundries during this two-year period expect casting production to increase 15 per cent in 1960 and 20 per cent in 1961.

The foundrymen who will do this purchasing will be making their buying plans at the AFS Castings Exposition—the only industry-wide and representative show to be held during the next two years. Leading equipment manufacturers and suppliers will be there since it will be their only opportunity to personally reach 15,000 foundry executives, technical and operating men in the short span of one week.

An indication of the changes within the industry is the number of new exhibitors at the Exposition. Forty of them will be showing products for the first time. More than 200 have previously participated.

Whether the exhibitors are new or old, the emphasis is on new equipment which will allow foundrymen to produce better castings at a lower cost. Typical of this new equipment are:

New Process Produces Pure Nickel Patterns to Exact Tolerances from Wood, Metal or Plastics

A revolutionary method of making metal patterns, core boxes and permanent molds will be presented for the first time to the general public at the Castings Exposition by the Carbonyl Metal Products Div., The Budd Co.

The process produces pure nickel patterns to exact tolerances from wood, metal or plastic models. It is based on the thermal decomposition of an organic compound of nickel.

Ceramic molds are made from the original model and placed in a deposition chamber. As the vaporized nickel compound contacts the heated mold, nickel is deposited at rapid rates to form a nickel shell of any desired thickness in an extremely accurate reproduction of the original model.

Finished patterns are produced in less time, have increased life, no shrinkage or warpage and require little if any machining.

Pallet Line System of Molding Speeds Production with Elimination of Lifting or Bending by Worker

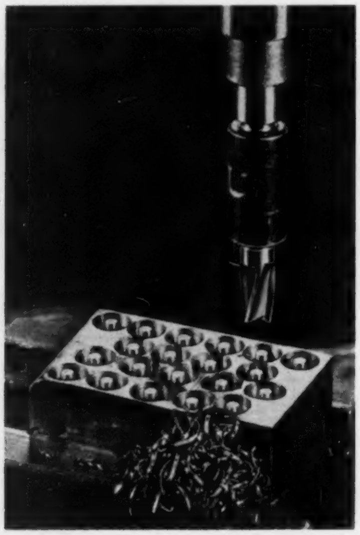
Pallet line system of mold handling with recent automation innovations cuts materials handling costs. Power-operated, fully automatic pallet car lift section, eliminates lifting or bending by molder to get pallet car from lower return run to upper pouring set-out level. See the Newago Engineering exhibit.

EXPOSITION

Exhibitors' Product Preview

New Sampling Device Aids in Chemical Analysis of Metals

A sampling device, using center cores from solid metal for use in chemical analysis, will be exhibited at the AFS Foundry Exposition. Laboratory Equipment Corp., St. Joseph, Mich., manufactures the drill-like device, called a trepanning tool. It provides a pin sample with relatively low surface area to weight ratio and practically eliminates graphite loss providing more precise carbon determinations.

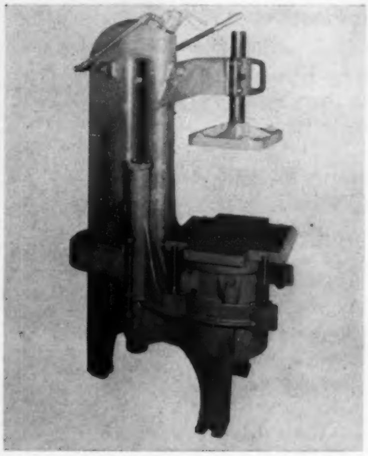


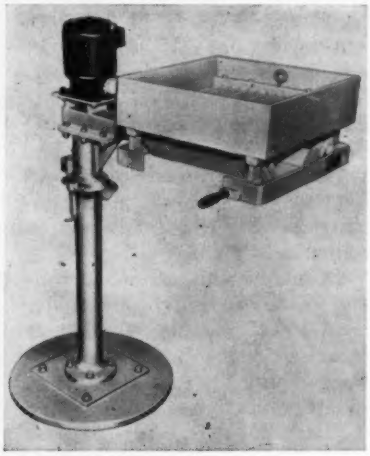
Beardsley & Piper will Introduce Foundry-Mite Line at AFS Castings Exposition in Philadelphia

Showplace of the foundry industry, the AFS Castings Exposition, has been selected by Beardsley & Piper Div., Pettibone Mulliken Corp., for the unveiling of the Foundry-Mite line. This supplements the B&P line usually associated with the manufacture of large foundry equipment.

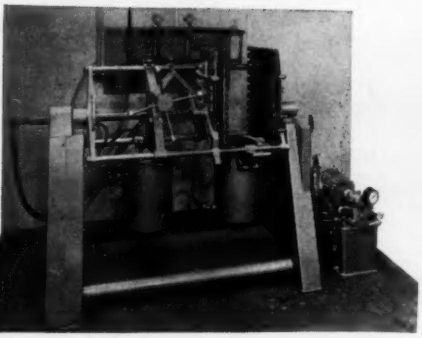
Included in the equipment are bench and floor model Vibra Draws, wire straighteners, wire cutters, electric riddles, jolt-squeeze machinery and Screenarators. These will be sold through the existing B&P sales force plus an extensive agency system. The equipment will be promoted both individually and as a line.

Says B&P vice-president and general manager C. V. Nass, "While we have always sold smaller equipment, it seems that we are primarily identified as a manufacturer of large equipment. This seems to have overshadowed the fact that we do produce smaller, but nonetheless effective machinery that does fill a specific need in both small and larger foundries."





Hydraulically-Operated, Adjustable Speed Shell Core Machine Features 1-Minute Production



Shell cores for ferrous, non-ferrous, shell or permanent molds may be produced in various lengths in less than a minute on the new 400 line of shell core machines to be shown by Dependable Shell Core Machines, Inc., Portland, Ore.

The machine with adjustable speed, is hydraulically powered for fast, semi-automatic production of the largest shell cores. Face plates are wide and "T" slotted to allow core boxes to be changed with minimum shutdown. Unit uses natural or manufactured gas heat, applied directly to the core box. Hydraulic systems can be located beside or away from the machine. See this machine in operation at the AFS Exposition, May 9-13.

Fully Automated Pouring Device Saves Manpower and Metal with Elimination of Human Element

Fully automated pouring device developed for mechanized, high-production shop using either continuous car type or indexing type mold conveyor, saves manpower and metal by eliminating the human element. The entire sequence of operations is tied-in to the conveyor motion by either a program cycler or by direct control elements.

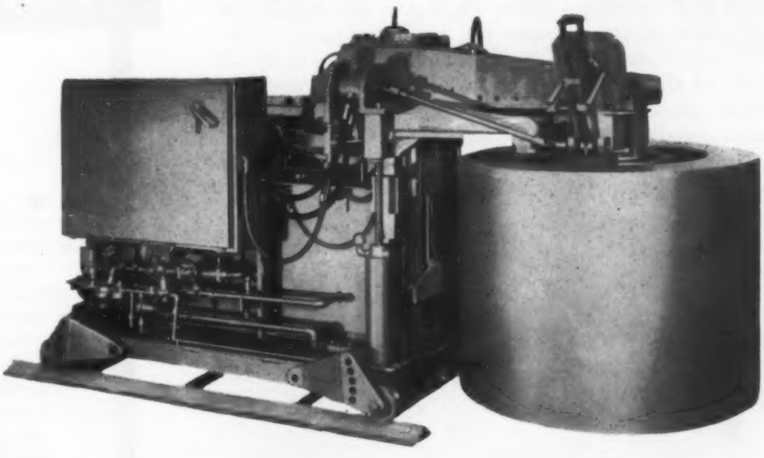
"Pourmatic" has 350 lb capacity (ferrous) and will fill approximately 100 molds hourly. Two pouring ladles can be serviced from one holding ladle. For additional information see the display at the Castings Exposition by International Automation Corp., Ann Arbor, Mich.

British Moulding Machine Co. will Operate Two Automatic Molding Machines

Booth model of operating exhibit by British Moulding Machine Co., Ltd., Faversham, Kent, England. One man will operate two automatic molding machines producing 240 parts hourly in 16x16x22-in. flasks. Among new and improved equipment to be shown will be a drag turnover machine and mold closing equipment used with the automatic molding machines.

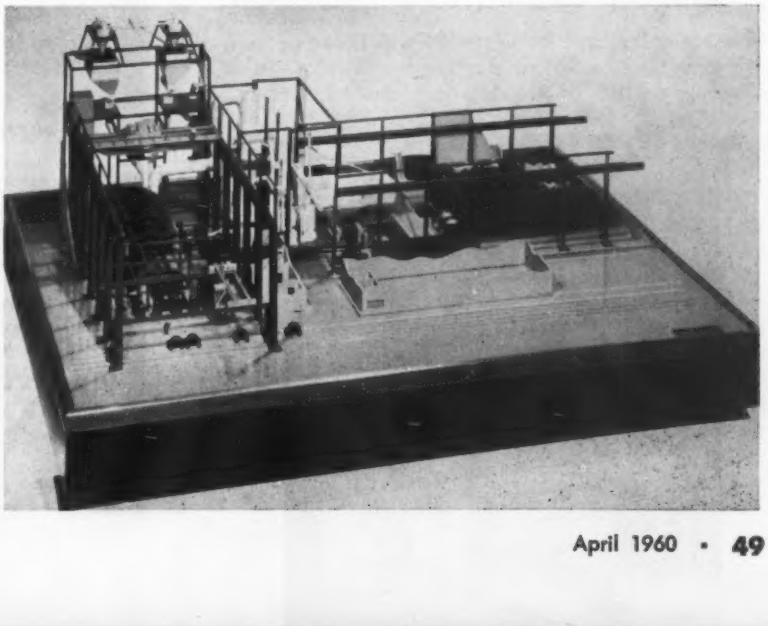
Automatic Aluminum and Brass Castings Machine May be Used with Practically All Aluminum Alloys

Automatic aluminum and brass casting machine produces fine-grained, close-tolerance castings or slugs from metal purchased in its least expensive form, pig, ingot or scrap. Casts practically all aluminum alloys including pure aluminum and all wrought alloys that cannot be die cast. Molds can be made to accommodate symmetrical or more complex shapes from 1/2 in. to 6 in. in depth and 3/8 in. and up in diameter. Como-Cast Corp., subsidiary of Basic Products Corp., will have unit operating mechanically at the Castings Exposition.



Look into Future of Foundry Melting Practices will be Feature of Lester B. Knight Exhibit

A revolution in the steel casting industry, the use of the cupola-oxygen conversion technique, reportedly is close to reality. Although no such installation exists today in the foundry field, primary steel mills use the process for the production of ingots. See the Lester B. Knight & Associates booth for a scale model showing a proposed melting area in a large steel foundry.

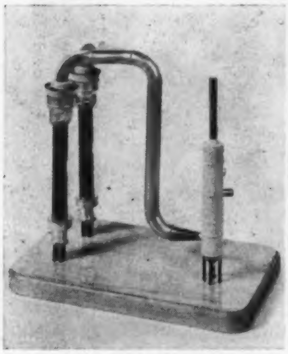


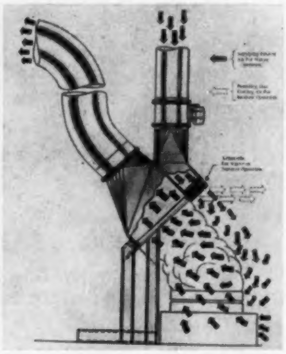
EXPOSITION

Exhibitors' Product Preview

Claude B. Schneible to Feature 2-Step Method for Reducing Cupola Fly Ash To a Minimum

Reduce cupola fly ash to a minimum with two-step approach by Claude B. Schneible Co., Detroit. Step No. 1 is the cupola collector consisting of a heavy steel shell extending above the top of the cupola, an adjustable deflector cone and an entrainment shelf. This unit meets code requirements in practically all parts of the country. Step No. 2 is the gas scrubber which provides the maximum gas scrubbing that is mechanically possible to obtain and may be adapted to Step No. 1 to satisfy future codes. See this and other Schneible products at the Castings Exposition.





Carver Foundry Products Co. will Exhibit Dry Sand Reclaiming Unit Featuring Flexibility

Dry sand reclaiming unit, said to reclaim 75 per cent or more on sand investment at speeds of four tons or more per hour, will be exhibited at the Castings Congress by Carver Foundry Products, Muscatine, Iowa. Unit, designed for flexibility which can be used with a vertical bucket or slanting bucket elevator or conveyor, consists of a heavy-duty crusher, elevator,

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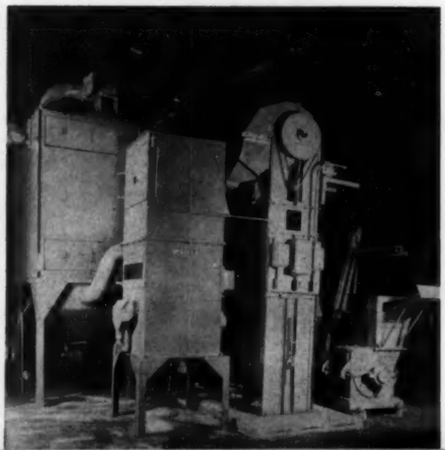

1960 CASTINGS CONGRESS PAPERS

■ The technical articles appearing in this preview section of MODERN CASTINGS are the official 1960 AFS Castings Congress papers — the most authoritative technical information available to the metalcasting industry.

Nearly 100 technical papers are scheduled for presentation at the 64th Castings Congress of the American Foundrymen's Society at Philadelphia, May 9-13, 1960. About 50 papers will be pre-printed here prior to the Congress.

■ *Written discussion of these papers is welcomed and will be included in the publication of the 1960 bound volume of AFS TRANSACTIONS. Discussions should be submitted to the Technical Director, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.*

■ Readers planning to participate in oral discussion of these papers during the 64th Castings Congress are advised to bring them to the technical sessions for ready reference.

NOW AVAILABLE:

The new case-bound Volume 67, 1959 AFS TRANSACTIONS. Contains technical papers presented at the 1959 AFS Castings Congress, discussions of papers, Annual Reports, and Minutes of Board of Directors Meetings. 808 pp. Price: $10.00 (members); $15.00 (nonmembers). Address orders to: Book Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

SOLIDIFICATION OF METALS

general principles

by G. W. Form and J. F. Wallace

ABSTRACT

The mechanism and factors influencing the solidification of metals are reviewed based on an analysis of the pertinent literature. The underlying phenomena of nucleation and growth are first described for the solidification of a pure metal and subsequently extended to the freezing of single-phase solid solutions and eutectics. The influence of various characteristics of phase diagrams, different rates of solidification and crystallographic structures on the solidification process are listed.

The control of the as-cast grain size is covered in considerable detail because of its commercial significance. The effect of rapid cooling, mechanical vibration and addition of substances for inoculation and restriction of growth on grain refinement is reviewed and the mechanism of each of these factors analyzed. The functioning of several commercial grain controlling additions in solid solutions and eutectic alloys is described.

INTRODUCTION

This has been prepared as the first or introductory article in a series to describe the solidification phenomenon to the foundryman. The factors governing solidification and methods of controlling this process are of great importance in determining the properties of cast metals. Heat treatment can be employed to modify the as-cast properties in some respects, but many facets of the original cast structure do persist and influence the final properties markedly.

This first report will present our existing state of knowledge of solidification on a general and largely theoretical basis. As such, this paper is primarily a critical review and analysis of the pertinent technical literature.

Systematic solidification studies have been made over more than 40 years.[1] However, the gathering of the required data has been delayed by the great experimental difficulties encountered in such studies primarily due to the relatively rapid rates of reaction and the numerous variables involved during freezing.

Considerable emphasis has been placed upon studies of solidification recently, however, and this interest and activity will undoubtedly improve our understanding. Subsequent papers will discuss the solidification process and how control measures can be instituted for individual types of cast metals.

THE LIQUID AND SOLID STATES

Since solidification is a transformation from liquid to solid, the nature of the initial state must unquestionably have some bearing on the end product. It is therefore appropriate to examine the liquid state first. A number of general publications are available in which liquid structure and behavior are summarized.[2-6] In general, these treatises analyze the liquid state in the light of its intermediate position between the gaseous and the solid state.

Several factors suggest strongly that the liquid has greater similarity to the solid than to the gaseous state. For instance, the volume change and the heat of transformation attending solidification are small compared to the corresponding values involved in liquefaction. This evidence indicates that the liquid structure is characterized by a densely packed atomic configuration, and that solidification does not necessitate extensive rearrangement of this configuration. X-ray diffraction studies[7] confirm that the atomic arrangement in the liquid (at least close to the melting temperature) is not as chaotic as in the gaseous state, but that a certain degree of order exists in the immediate vicinity of any given atom. However, at large distances from a given atom this order is replaced by complete randomness. Consequently, the atomic arrangement in the liquid can be considered as one which exhibits local or short-range order, but long-range disorder.

However, the short-range order in the liquid is transitory in nature, since it only persists for a short time in a given small region, disintegrates and forms in another area.[8] The lower the temperature in the liquid, the more stable become the short-range order groupings.

G. W. FORM is Asst. Prof. and J. F. WALLACE is Assoc. Prof., Dept. of Met. Enrg., Case Institute of Technology, Cleveland.

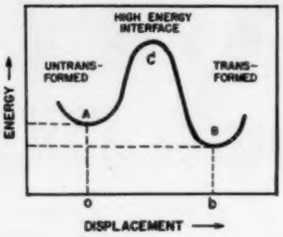

Fig. 1a — Energy relationship during a phase transformation.

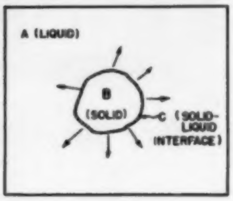

Fig. 1b — Advance of the high energy interface (c) into the untransformed region (A).

Most theories designed to describe the properties of liquids consider the liquid state as being close to the solid, except that more "sites" (identified with holes or vacancies) are empty in the liquid phase. These theories do account for such properties of metals as fluidity, diffusivity, compressibility and specific volume, but none are capable of completely explaining all aspects of the melting or freezing process.

These theories also fail to explain why liquids can be undercooled considerably. If "subsize crystals" or short-range order groupings do exist in the liquid, it would be expected that these would grow as soon as the thermodynamic melting temperature is reached without appreciable undercooling. This apparent discrepancy led to the proposition[9] that the atoms in the liquid state assume a configuration which is not that of the solid, although coordination number and interatomic spacing may be similar.

It is shown that such a configuration may have a lower energy than the one which would more closely correspond to the atomic arrangement in the solid. This argument, if correct, may be taken as evidence that freezing is not merely an extension from short-range to long-range order, i.e., it can not simply be regarded as a disorder-order transformation.

Solid Metal Structure

The atoms of a solid metal are positioned in a regular arrangement, fixed relative to one another in accordance with one of several possible crystal structures. Minimum energy considerations, primarily those involving the electron configuration, govern the particular structure which a metal assumes consistently upon solidification.

Although the arrangement of atoms is interspersed with a large number of lattice imperfections, particularly in the vicinity of the melting temperature, solid metals at all temperatures exhibit a high degree of crystalline regularity,[10] with the distances between the atoms fixed by strong interatomic forces.

Transformations from liquid to solid can then be described as changes from a more open structure, in which the atoms are loosely held in place in a transitory arrangement, to a closely packed configuration with strong interatomic binding forces and fixed atomic sites. The difference in binding energy between the two states is released during the transformation as latent heat of fusion.

FREEZING OF A PURE METAL

The solidification of a pure metal will be reviewed first because of the relative simplicity of this change. Transformation from one equilibrium state (liquid) to other (solid) requires the system to pass through intermediate states of higher energy as shown in Fig. 1a. If the entire system transformed simultaneously, all of the material involved would be in a state of high energy at a given time.

To minimize the amount of material in this intermediate high energy state, the system transforms gradually, i.e., by a nucleation and growth process. Small stable regions of the solid phase, called nuclei, are formed, being separated from the liquid by a sharp boundary (Fig. 1b). It is only the material in this boundary which at any time during the transformation is in the high energy state.

Thus, from a kinetic viewpoint, freezing involves the formation of small stable solid regions (nucleation), and the advancement of the high energy boundary into the untransformed liquid phase (growth).

NUCLEATION OF A PURE METAL

The most difficult stage of the solidification process is the formation of a stable nucleus with its high energy boundary. If the work required to form a stable nucleus is the same throughout the entire melt, a condition of homogeneous nucleation prevails. However, if preferred sites exist, where nucleation can occur more readily than in others, heterogeneous nucleation is obtained. Homogeneous nucleation occurs rarely from a metallic melt because preferred sites that facilitate nucleation, such as mold walls or foreign particles, nearly always exist.

The principles underlying nucleation from the melt can best be demonstrated by the theory for homogeneous nucleation.[11,12] According to this theory, fluctuating clusters of atoms, called embryos, exist in the liquid and tend to grow to stable nuclei. In order for a cluster of atoms to reach stability, the free energy difference between the solid and corresponding liquid embryo volume must be large enough to provide for the high energy interface between embryo and melt.

Atom Growth

For this reason, the embryo must grow to a certain critical size, since for a smaller particle the surface-to-volume ratio is too high for the above condition to be

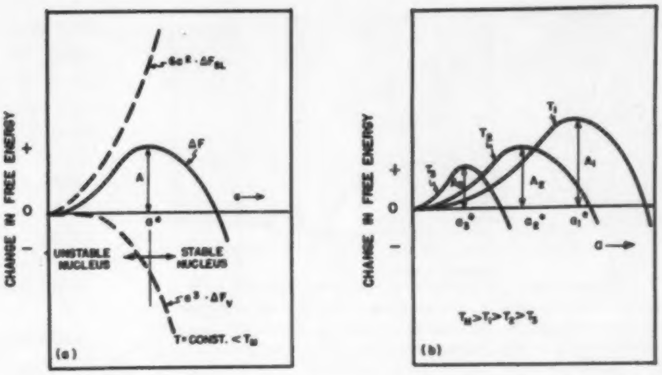

Fig. 2 — Change in free energy during formation of a cubical nucleus in a melt. a) Free energy change at one given temperature below the theoretical melting temperature T_M. b) Total free energy change at three different temperatures below T_M.

met. Once an embryo has reached the stable nucleus size, it can grow rapidly with an attendant decrease in free energy.

The prevailing energy relations for nucleation can be expressed in the following way: the local free energy change resulting from the formation of a solid particle of unit volume (ΔF) is composed of the difference in chemical free energy between liquid and solid per unit volume (ΔF_v), and of the interfacial free energy between the two phases per unit area (ΔF_{sl}).

For a cubical embryo of edge length a:

$$\Delta F = a^3 \cdot \Delta F_v + 6\, a^2 \cdot \Delta F_{sl} \qquad (1)$$

The positive surface energy term varies with the square of the edge length, while the chemical free energy term, which is negative below the melting point, varies with the cube of the edge length. Therefore, if the total change in free energy (ΔF) is plotted against edge length a at a given supercooling temperature, a maximum will be observed at a critical edge length a^*, as shown in Fig. 2a. Up to this length, the embryo is unstable, because its growth requires an increase in free energy.

Work of Nucleation

Nuclei with $a > a^*$ are stable since they can grow with a decrease in free energy. The maximum free energy change that occurs at the critical nucleus size is called work of nucleation (A), since it represents the magnitude of the energy barrier which has to be surmounted before a group of atoms can become a stable nucleus. By differentiating equation (1) with respect to a, and setting the first derivative equal to zero, the work of nucleation becomes:

$$A = 32. \cdot \Delta F_{sl}^3 / \Delta F_v^2 \qquad (2)$$

At the equilibrium or thermodynamic melting temperature (T_m), ΔF_v equals zero, the work of nucleation is infinite and a stable nucleus will not form, although fluctuating clusters of atoms do exist. For this reason, the freezing of a metal invariably requires undercooling. As the degree of undercooling increases both the activation energy A and the critical nucleus size a^* are reduced, as indicated schematically in Fig. 2b.

Therefore, the rate of nucleation first increases as the undercooling increases. However, the formation of discrete groupings of atoms in the liquid which at a given temperature grow to stable nuclei is assisted by thermal fluctuations, making the process of nucleation a statistical one. As the temperature decreases, the intensity of these fluctuations diminishes, the movement of the atom is slowed down and the rate of nucleation is eventually reduced, despite a continuously decreasing activation energy.

Thus, with increasing degree of undercooling the nucleation rate first increases, attains a maximum and decreases at lower temperatures (Fig. 3). The rate of nucleation will also vary proportionally with the volume of the sample under consideration, and inversely proportional with the interfacial energy between liquid and solid.[13]

Heterogeneous Nucleation

The free energy considerations for homogeneous nucleation can readily be extended to heterogeneous nucleation occurring on a foreign particle or at the mold wall. In this case, allowances are made for the surface energy between the foreign particle and the liquid (ΔF_{lp}) and that between the foreign particle and the solid (ΔF_{sp}). For nucleation on a flat-sided foreign particle, the static equilibrium relation between the three interfacial free energies per unit area requires that:

$$\Delta F_{lp} = \Delta F_{sp} + \Delta F_{sl} \cdot \cos \Psi \qquad (3)$$

The significance of Ψ, the contact angle between the foreign particle and the parent solid, is shown in

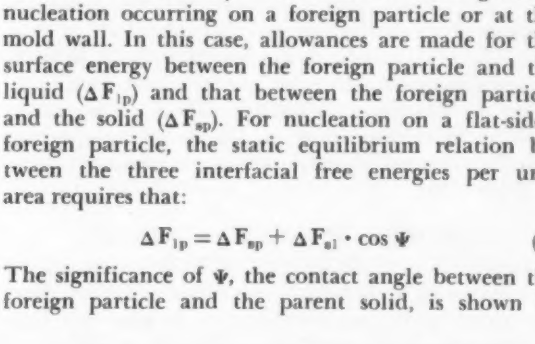

Fig. 3 — Supercooling effect on rate of nucleation (T_M = thermodynamic equilibrium melting temperature).

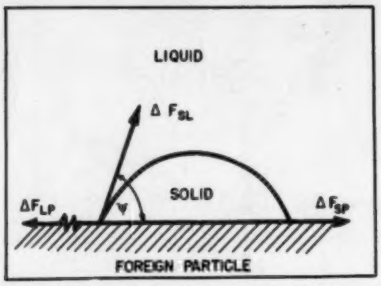

Fig. 4 — Relationship between interfacial free energies and contact angle Ψ for the case of heterogeneous nucleation on a flat foreign particle. SL — solid-liquid; SP — solid-particle; LP — liquid-particle.

Fig. 4. Following the method used for homogeneous nucleation, the activation energy in the case of heterogeneous nucleation is:

$$A_1 = \frac{32 \cdot \Delta F^3_{sl} \dfrac{[(2+\cos\Psi)(1-\cos\Psi)^2]}{4}}{(\Delta F_v)^2} \qquad (4)$$

Comparing equation (4) with (2), it can be seen that the activation energy for heterogeneous nucleation is never larger than that for homogeneous nucleation. When Ψ equals 180 degrees (no wetting between solid and foreign particle) the activation energies of the two cases are the same. Homogeneous nucleation is the most unfavorable condition for nucleation, since it requires the highest activation energy, and therefore the largest degree of undercooling.

Any foreign particle which wets the parent solid to some extent will facilitate nucleation. Since such particles are almost always present, this explains why heterogeneous nucleation most often prevails in practice. The effectiveness of foreign particles in reducing undercooling depends upon the value of the contact angle Ψ. These principles of heterogeneous nucleation are fundamental in controlling inoculation and will be discussed in detail in the section on control of grain size.

GROWTH OF CRYSTAL NUCLEI

As soon as a stable nucleus has been formed in the melt, it tends to grow by acquisition of atoms from the liquid. If the undercooling of the melt has been considerable, growth of the solid crystal will occur rapidly. If the undercooling has been sufficient, complete solidification may occur without any abstraction of heat from the system. The heat of fusion in this case is dissipated into both the solid and liquid as solidification occurs.

If, on the other hand, the undercooling of the melt has been slight, the heat of fusion rapidly brings the melt to the equilibrium melting temperature, and growth can only proceed if heat is abstracted from the system. This is the condition prevailing in practice. The heat in this latter instance is only lost to the solid. Accordingly, freezing is effectively a nonequilibrium process which occurs over a range of temperatures.[14] The speed at which a particle grows depends on the amount of undercooling and on the rate at which the latent heat of fusion can be removed.[15]

Growth Rate

Since the potential growth rate is orders of magnitude larger than the rate of heat removal based on heat conductivity considerations, once the remaining melt has been heated to the equilibrium melting temperature any further growth is entirely dependent on heat removal.[16] In this latter case, the rate of growth depends upon the temperature gradient in the solid metal, heat conductivity, specific heat, heat of fusion of the metal, as well as on the heat abstraction capacity of the mold.

Figure 5 illustrates the anticipated temperature distribution adjacent to the solid-liquid interface for the case of limited (a), and for the case of considerable (b), undercooling of the melt. Since in practice continued growth necessitates removal of heat and thus a finite temperature gradient, it follows that growth of crystals does not occur at random but in an opposite direction to that of heat flow from the system.

Crystallographic Aspects

In addition to thermal factors, crystallographic aspects must be considered in crystal growth.[17] The facility with which atoms in the melt can be attached to the surface of a growing crystal depends on the orientation of the latter; in other words, the linear velocity with which a crystal plane can propagate parallel to itself is governed by the geometry and type of bonding prevalent in the atomic arrangement of this plane.

The effect of crystal orientation on the growth rate has been illustrated on supercooled selenium inoculated with selenium seed crystals of different orientations.[18] Also, the relationship between growth anisotropy and atomic bonding has been demonstrated with NaCl–crystals.[19]

The role of imperfections, such as screw dislocations, in permitting indefinite growth of a single spiral crystal face without requiring nucleation of new planes parallel to existing ones,[20] indicates that additional atoms tend to be added to a growing par-

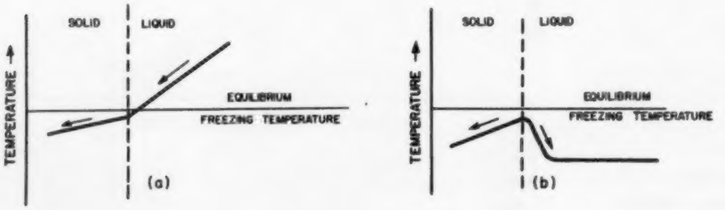

Fig. 5 — Temperature distribution adjacent to the solid-liquid interface.[15] a) The bulk of the liquid is at a temperature above T_M — thermal conditions conducive to slow growth. b) The bulk of the liquid is at a temperature appreciably below T_M — thermal conditions conductive to rapid growth.

ticle at locations in which they can be held firmly in place by atoms on several sides.

Importance of Factors

The importance of thermal and crystallographic factors can readily be seen from the appearance of normal cast structures such as shown in Fig. 6. Solidification in a casting starts invariably at the mold walls, where a large number of fine crystals of random orientation can be nucleated to form the chill zone.

Because of the anisotropy of the growth rate, those crystals whose direction of maximum linear growth is parallel (but opposite) to that of heat flow will grow faster and crowd out the other crystals of less favorable orientation. A second zone, called columnar zone, with a strongly preferred orientation will thus form adjacent to the chill layer. The speed of growth of the columnar grains in a pure metal will depend on the rate at which the heat can be abstracted in the case of limited undercooling of the melt.

The columnar zone usually extends to the center of a casting of pure metal, but may, in some cases, be followed by another zone of equiaxed, randomly oriented grains in the center region of solid solutions. It has been shown[2] that the preferred growth direction in the columnar zone of body-center-cubic and face-center-cubic metals is the cube axis, while any axis in the close-packed plane of hexagonal close-packed metals can act as the preferred growth direction.

The columnar zone may consist of either polyhedral crystals or dendrites.[14] The occurrence of dendritic solidification requires supercooling of the liquid adjacent to the solid-liquid interface.[21] Generally, dendritic solidification will not occur in a pure metal or be restricted to only a minor fraction of the thickness of the casting[17] because the rate of heat abstraction is slower than the speed of dendritic growth. The presence of dendrites in the columnar zone of pure metals can only be observed if the ingot is dumped during the period when this type of solidification is in progress.

SOLIDIFICATION OF ALLOYS

Three phenomena increase the complexity of the solidification process in alloys compared to pure metals. First, more than one solid phase may form from a single homogeneous melt; second, the solid phase rejected from the melt has a different composition than the liquid from which it originates; and third, solidification occurs over a range of temperatures rather than at a single freezing temperature. The freezing of two types of alloy systems will be discussed in this paper: a single-phase binary solid solution alloy and a two-phase eutectic. It is assumed that complete liquid solubility exists in each case.

SOLID SOLUTIONS

The solidification of a melt into a single-phase solid solution is considered first. Despite the fact that solidification is a nonequilibrium process, some of the aspects of alloy freezing can best be illustrated with the help of the equilibrium diagram. In Fig. 7 the upper left-hand corner of the common type of equi-

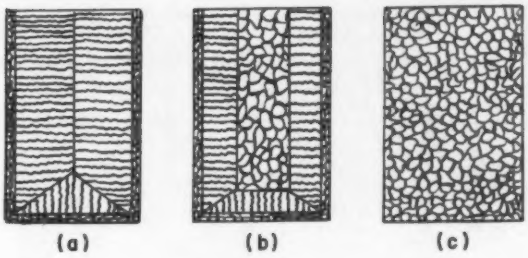

Fig. 6 — Appearance of ingot structures a) wholly columnar (except for chill zone); b) partially columnar and partially equiaxed; c) wholly equiaxed.

librium diagram for the above alloys is schematically drawn.

In this diagram, as the amount of solute element *B* is increased, the melting point is decreased below that of the solvent *A*. The alloy under consideration has an overall composition of *C*. Under equilibrium cooling conditions freezing will start at T_o with the rejection of solid of composition C_{so}, and is complete at T_f with the rejection of a solid of composition *C* from the melt of composition C_{lf}.

Thus the average composition of the liquid varies from *C* to C_{lf} during solidification, while that of the solid changes from C_{so} to *C*. The ratio between solute concentration in the solid to that in the liquid is referred to as distribution coefficient K_o. The average melting temperature of the untransformed liquid decreases along the liquidus line during solidification. Under equilibrium conditions, diffusion is allowed to occur to such an extent that a homogeneous solid phase of composition *C* is obtained upon complete solidification.

Solidification Zones

Since freezing within a binary alloy casting proceeds over a range of temperatures, three distinct zones generally occur across the section while solidification is in progress:[22] a completely solid volume adjacent to the mold followed by a mushy zone containing

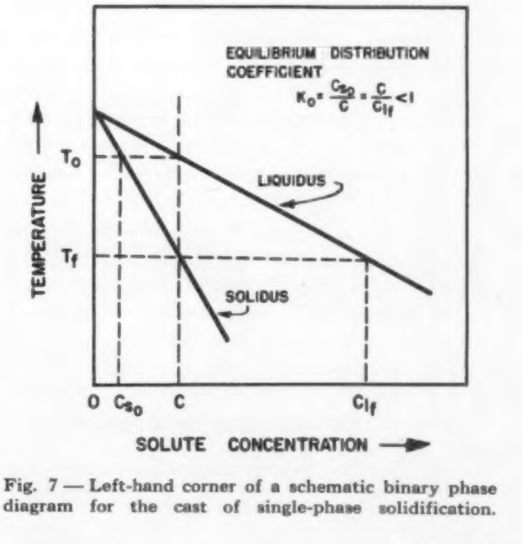

Fig. 7 — Left-hand corner of a schematic binary phase diagram for the cast of single-phase solidification.

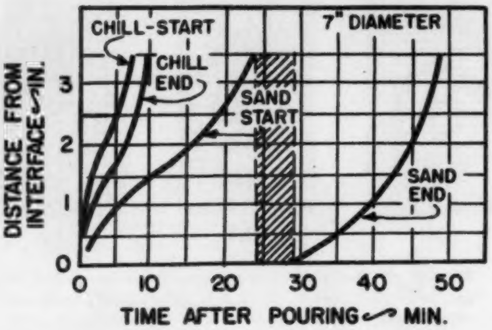

Fig. 8 — Freezing rate effect on start and end of solidification of a 0.60 per cent carbon cast steel.[23] The shaded area delineates the time involved during which the entire sand casting is mushy.

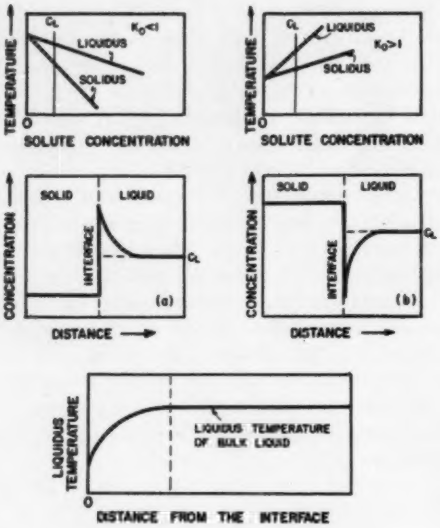

Fig. 9a and 9b — Solute concentration adjacent to an advancing solid-liquid interface during alloy solidification. 9a — Addition of solute to lower the liquidus ($K_o<1$). 9b — Addition of solute to raise the liquidus ($K_o>1$). 9c — Variation in liquidus temperature adjacent to the interface due to solute buildup (holds for $K_o<1$ and $K_o>1$).

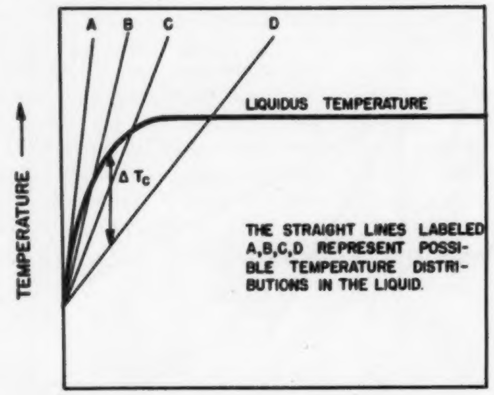

Fig. 10 — Liquidus temperature and possible temperature distributions in the liquid as a function of distance from the interface during alloy solidification.[16]

both liquid and solid, and a completely liquid zone in the center.

The width of the mushy zone for any specific alloy at a given time will depend primarily upon the rate of heat removal from the casting. The influence of a chill and sand mold upon the length of the mushy zone in a 7 in. square bar casting produced from a 0.60 per cent C steel is shown in Fig. 8.[23] It is noted that after 24 to 28 min the mushy zone extends across the entire 7 in. section of the sand casting.

If solidification occurs at so fast a rate that the atoms cannot diffuse sufficiently to produce compositional equilibrium, a concentration gradient is set up in the liquid adjacent to the advancing solid-liquid interface. This buildup is produced by the local enrichment of the liquid melt with *B*, as is shown in either Fig. 9a or 9b, depending on the type of equilibrium diagram.

Since the liquidus temperature varies with composition, it will change, adjacent to the solid-liquid interface, for both cases *a* and *b* in the manner shown in Fig. 9c. If the slope of this liquidus curve at the interface is steeper than the temperature gradient in the melt, the liquid metal adjacent to the interface is said to be constitutionally supercooled.[17]

Solute Buildup

The buildup of solute in the liquid at the interface reduces the liquidus temperature of this portion in the melt. Since the rate of diffusion to remove this high-solute layer is much slower than the rate of heat removal, the net result is to decrease the rate of dendritic growth.[16] If the temperature gradient in the liquid falls to below a certain critical value, columnar (usually dendritic) growth can be arrested and replaced by equiaxed grain growth.

Nucleation of new equiaxed grains requires that a critical degree of undercooling (ΔT_c) be reached. In Fig. 10 this stage is assumed to be attained by the temperature distribution *D*. In this case, new grains can form in the liquid ahead of the advancing interface, thereby prohibiting continued advancement of the columnar zone. The equiaxed zone will, in turn, solidify dendritically until all supercooling has been eliminated.[17]

In the case of sufficient supercooling, dendritic growth of the equiaxed crystals may prevail until the end of solidification. As the grains in the equiaxed center portion grow radially, a solute concentration gradient will also buildup at the interface of each grain. As a result, solute is trapped in the grain boundaries when freezing is complete.

The variation in ratio of equiaxed to columnar zone length is:

a) Inversely proportional to the effective superheat.
b) Inversely proportional to the critical degree of supercooling ΔT_c, necessary for nucleation to occur at a reasonably high rate.
c) Proportional to the freezing range.
d) Inversely proportional to a function of the thermal parameters, i.e., the ratio becomes smaller as the thermal conductivity decreases because of alloying.[16]

This nonequilibrium cooling is also responsible for segregation in the solidifying alloy. The buildup of the high-solute layer, illustrated in Fig. 9a and 9b, usually persists throughout solidification since the rate of heat removal is normally much larger than the rate of diffusion of the solute in the liquid.[16,24]

Segregation

The overall segregation is obtained because of the higher solute solubility in the liquid, resulting in a variation in the solute concentration of the solid crystals rejected from the liquid throughout the freezing range. The extent and distribution of segregation that prevails in a casting depends primarily upon the rate of solidification.[25]

First, for very slow (virtually equilibrium) freezing conditions of a type practically never encountered in commercial castings, sufficient time is allowed for diffusion of the solute in both the liquid and the solid and no segregation results. Intermediate freezing rates produce large overall segregation. However, if freezing occurs rapidly compared to diffusion in the liquid the well-known end-to-end segregation is observed, characterized by negative segregation near the mold wall and positive segregation in the regions which solidify last.

The segregation occurring in the interdendritic areas is referred to as microsegregation, and is due to the fact that the dendrites protruding into the liquid act as barriers against solute diffusion in the liquid. The important factors influencing segregation are the equilibrium distribution coefficient K_o (Fig. 7), the freezing rate and the temperature gradient in the liquid.[26]

EUTECTICS

The second type of alloy that will be discussed is a binary eutectic in which the components have restricted solid solubility, as illustrated by the phase diagram in Fig. 11. A single temperature exists (called eutectic temperature) at which the liquid is simultaneously saturated with both terminal solid solutions, indicated as α and β. The simultaneous rejection of these two solid phases from the melt is referred to as eutectic reaction, and is described by the following relationship:

$$\text{liquid} \rightleftarrows \alpha - \text{solid} + \beta - \text{solid}$$

In binary systems, the eutectic reaction is the only type of freezing during which a homogeneous liquid decomposes directly into two solid phases. Under slow cooling conditions, only alloys having a composition lying between *a* and *b* will undergo the eutectic reaction. Eutectic freezing is a process involving nucleation and growth, and its mechanisms are the same as for single phase alloys.

The solidification process is appreciably influenced, however, by the fact that a eutectic involves the freezing of two separate solid phases. The following discussion is limited to the description of the solidification of only the eutectic composition without reference to proeutectic phases.

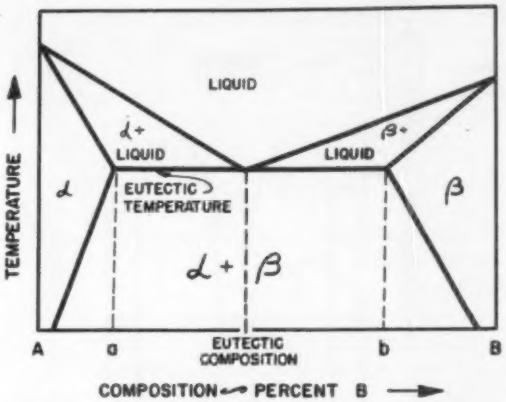

Fig. 11 — Schematic representation of a binary eutectic phase diagram.

Primary Phase

The first phase to be nucleated will be that requiring the least undercooling, which is dependent upon the effectiveness of the foreign nuclei in the melt. The primary phase, once nucleated, may serve as nuclei for the secondary phase, or further undercooling and accompanying alloy segregation may be necessary before the second solid phase can form.

If the primary phase nucleates the secondary phase, the resulting eutectic is referred to as normal. If the second phase is nucleated independently in the liquid, the resulting eutectic is called anomalous. The two important commercial eutectics, austenite-graphite and Al-12 per cent Si belong to the group of anomalous eutectics.[27,28] In order that the second phase may be nucleated independently in the liquid, the interfacial energy between the α- and β-phase must be greater than that between the second phase and the foreign particle on which it might nucleate.[27]

This prerequisite is in line with the principles of heterogeneous nucleation outlined earlier. On the basis of data collected from a large number of eutectics, Scheil[28,29] found that anamalous eutectics occur only if the ratio of the volume fraction of the two phases involved remains below a certain value.

The primary solid is always present in the larger amount, and in most cases envelops the secondary solid making the latter a discontinuous phase. Moreover, the principal constituent of the secondary or discontinuous phase has always an appreciably higher melting temperature than that of the primary phase.

Normal and anomalous eutectics can readily be distinguished from one another by metallographic analysis. In the case of the anomalous mixture, the second (and discontinuous phase) is characterized by its irregular shape and random orientation, while in the normal eutectic the second phase possesses a definite and simple shape such as rod, sphere or lamella, as well as a definite crystallographic orientation.[29,30] Since the shape of the second phase is also affected by the cooling rate, more than one morphology may be encountered in a given eutectic.

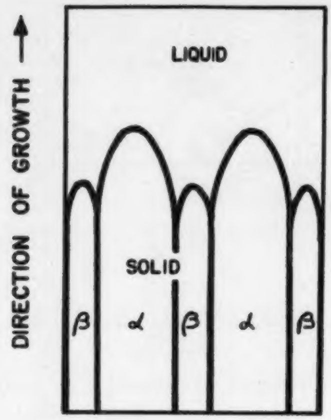

Fig. 12 — Schematic representation of a lamellar eutectic advancing into the liquid under steady state growth conditions. Phase α is the leading phase.[27]

Binary Eutectic

While many facets of the solidification of an anomalous eutectic are similar to those found in single-phase alloys, normal eutectics solidify in a considerably different manner. These differences arise because the two phases in normal eutectics grow as a unit and impose restrictions on one another, as will be discussed for the lamellar morphology. Figure 12 illustrates a lamellar type A-B binary eutectic growing into the liquid.

As soon as a critical degree of undercooling is reached a primary α particle (rich in A) is rejected from the liquid. The attendant increase in B at the solid-liquid interface supersaturates the liquid with respect to this element, eventually forcing the nucleation of the second phase β on the α-particle. The formation of alternate layers of α and β may occur as a result of the overlapping of one phase over the edges of the other.[27]

This mechanism requires less undercooling than is necessary for the separate nucleation of each individual phase layer. This continued growth from one nucleus is analogous to spiral growth with the aid of screw dislocations as proposed for pure metals.[20]

Concentration Gradient

As the two phases grow into the liquid, the concentration gradient ahead of their respective solid-liquid interface increases, thereby decreasing the growth rate. This slowing down of the growth rate is counteracted by diffusion processes in the liquid which attenuate the concentration gradient. As soon as these two opposing tendencies balance, growth continues at a constant rate.

Since equalization of the concentration gradient occurs faster ahead of a thin than of a thick section, the growth rate would not remain constant if the section width should change during freezing. However, additional stability for steady state growth is provided by the interfacial energy between the phases. This energy increases as the width of the sections decreases, which tendency effectively counteracts thinning once steady state growth is attained.

The role played by the interfacial energy explains why the width of the phases is virtually constant throughout the entire eutectic mass for a given set of cooling conditions. Moreover, the faster the heat is abstracted the lower is the temperature at which the lamellas grow, and the narrower the resulting width of sections of the phases.

This latter fact is primarily due to the slower rate of diffusion for removal of the concentration gradient, and to a larger driving force (difference in bulk free energy) at lower temperatures which tend to shift the steady state growth condition in such a direction as to facilitate attenuation of the above concentration gradient, i.e., toward thinner lamellas.

The alternate layers of α and β grow from a single starting point in all directions until another group is contacted. Each group is called a grain, cell or colony. The direction of growth of eutectics is opposite to that of the heat flow, as was described for pure metals and single-phase alloys. If the axes of the lamellas in a particular grain do not coincide with this direction, the respective colony cannot grow to any appreciable size, since it is rapidly encroached by grains with a more favorable orientation for rapid growth. This can lead to conditions, where similar orientations or columnar structures in neighboring cells are observed.

The solidification of anomalous eutectics lacks the uniformity of the normal type, since no regular orientation exists between the two phases. Both phases usually solidify and grow in contact with the melt, but exceptions such as found in ductile iron appear to exist. While the two phases are interconnected in some anomalous eutectics, the minor phase in others is completely enveloped by the major phase.

CONTROL OF GRAIN SIZE

Since the size of the as-cast grain can exert a marked influence on segregation and mechanical properties, an effective means of controlling the grain size is of considerable importance. It is now possible to refine the grain size of aluminum and magnesium casting alloys as well as to control the eutectic cell size by special treatments. Work with other cast metals is presently in progress.

The refinement of the cast grain size requires that solidification start from a large number of locations, and that excessive growth of any one grain be avoided. This can be achieved in principle with three methods under the proper conditions. The success of these methods depends on the particular metal involved and on the thermal factors. The three methods are:

1) rapid cooling.
2) mechanical vibration.
3) addition of substances for the purpose of inoculation and restriction in growth rate.

Rapid Cooling Rate Effect

A rapid rate of cooling will chill a large portion of the solidifying casting to a temperature (below T_m) where the rate of nucleation is high (Fig. 3). Consequently, the number of available nucleation centers will be high particularly near the mold wall. The width to which one grain may grow before contacting its neighbors will necessarily be small. In pure metals, this rapid cooling tends to produce a finer though still columnar structure.

In alloys, however, continued growth of a crystal toward the center is not only dependent upon the rate at which the heat of fusion is abstracted, but also upon the speed at which the diffusion processes in the liquid can attenuate the concentration gradient at the solid-liquid interface. As the rate of heat abstraction is increased, this concentration gradient increases rapidly.

Consequently, the critical degree of supercooling for the onset of equiaxed growth may be reached within a shorter distance than is the case for slow cooling (if it is reached at all). When equiaxed grains do form in the center, these are finer during rapid solidification because of the increased fineness of the preceding columnar zone.

While columnar grains may be formed by slow cooling of alloys under some conditions,[31] it is also possible to obtain these columnar grains during rapid cooling of other alloys.[22] This latter condition can exist because steep thermal gradients prevent the attainment of the nucleation temperature ahead of the solid-liquid interface, despite an appreciable solute build up.

Equiaxed Crystallization

The factors governing the extent of equiaxed relative to columnar solidification of an alloy have been enumerated previously. It has also been found that the tendency toward equiaxed crystallization is governed in first approximation by the ratio of freezing rate to temperature gradient at the solid-liquid interface, and is a maximum when this ratio reaches its peak value.

The principal factor determining the magnitude of the above ratio is the degree of constitutional supercooling which can be attained. An alloy with a narrow freezing range, therefore, would exhibit a greater tendency towards columnar solidification than one with a wide freezing range.

Vibration has also been shown to be an effective means of grain refinement, and various mechanisms have been offered to explain this phenomenon.[32-43] It was proposed initially that grain refinement resulted from the fragmentation of the first crystals solidified in the melt, thereby increasing the number of stable particles which can act as nucleation centers. This proposed mechanism, however, fails to explain the coarsening of eutectic constituents when vibrated.

Pressure and Rarefaction Waves

A recent hypothesis[42,43] stating that the alternate pressure and rarefaction waves increase the centers for solidification by changing the stability of the phases according to le Chatelier's principle, offers more promise. The influence of the pressure wave in reducing the critical nucleus size, and thus increasing the number of nuclei is shown schematically in Fig. 13 for a metal that increases its density upon solidification.

These considerations hold equally well for a metal which expands on freezing, except that in this case the rarefaction wave serves to reduce the critical nucleus size, i.e., curves 2 and 3 in Fig. 13 are reversed. In order to account for the observed grain refinement it is necessary, however, that the nuclei formed during the pressure (rarefaction) period grow rapidly enough to remain stable during the rarefaction (pressure) period of the vibration, or that a standing wave system be established in the melt.

This latter mechanism is substantiated by the observation that metals which exhibit a large change in density during solidification can be more grain refined by vibration than those undergoing a smaller density change.[43]

In order to obtain grain refinement through vibra-

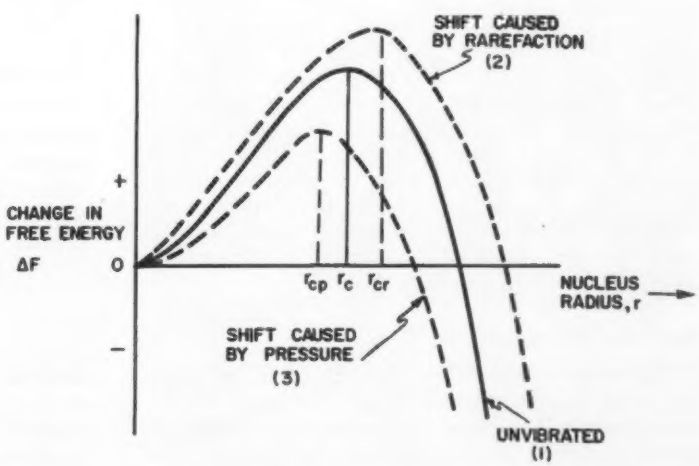

Fig. 13 — Pressure changes effect on free energy and size of stable nucleus.[36]

tions, two important conditions must be fulfilled. First, the pressure increase must be large enough to provide the critical degree of supercooling for effective nucleation. Second, the temperature gradient in the liquid must be sufficiently shallow so that the nucleation temperature can be reached in the melt ahead of the solid-liquid interface.

Additions Effect on Grain Refining

The above two methods of grain refinement have the disadvantage of either being applicable to castings of limited size or requiring extensive equipment, since it is obviously difficult to either chill or vibrate large metallic masses. The addition of substances for the purpose of grain refinement on the other hand is not subject to such limitations. The primary objective of this method is again to increase the number of effective nucleation centers and thereby produce a smaller grain size.

This purpose is achieved by providing stable nuclei and reducing the rate of grain growth while maintaining the proper control of thermal conditions. The effects of various additions on the as-cast grain size of metals and alloys has been widely studied.[44-59] These additions are best classified according to their purpose, i.e., whether they furnish stable nuclei (inoculation) or produce grain growth inhibition.

Inoculating particles must be solid at the melting temperature, and have a similar density as the liquid in order to avoid segregation. In addition, a strong adhesion (compared to cohesion) between the inoculant and parent solid is desired.[46] The important factors guaranteeing this strong adhesion are large forces acting between the two unlike atoms involved, and a minimum strain at the solid metal-particle interface.

The latter condition is fulfilled if crystallographic planes of easy matching are available. The forces between the atoms of the parent solid and foreign particle on the other hand are primarily determined by the electron configuration of the respective atoms. It is because of the interference of the chemical properties (electron configuration) of the atoms involved that particles of similar lattice disregistry with the parent solid act differently as inoculants.[46]

Since cases have been reported in which particles of considerable lattice disregistry can act as effective nuclei, it is apparently not always necessary that a suitable inoculant have a crystal structure similar to that of the solidifying phase, although this has been considered a necessary prerequisite for effective inoculation in the past. Apparently, the importance of the crystallographic factor can, in some instances, be overtaken by the chemical or electron configurational aspects.[60]

Inoculant Formation

The method used to introduce or form the inoculant is an important consideration and varies for different metals. To assure a large number of finely divided particles with clean and reactive surfaces, it is preferable to produce the inoculants by a reaction with constituents of the melt. Inoculants that tend to be made ineffecive by reaction with impurities or segregations should be added to the melt as late as possible and at as low a melt temperature as feasible. Other inoculants can be superheated and added to any time without reducing their grain refining capabilities.

The successful introduction of a suitable inoculant alone does not guarantee grain refinement, except in alloys which already contain a built-in grain growth inhibitor or in cases where the temperature is uniform throughout the entire melt. The latter condition seldom if ever prevails in practice; instead, a positive temperature gradient exists from the mold wall to the center (except at the solid-liquid interface, where the heat of fusion is liberated).

In order for the nuclei in the melt to become effective, the nucleation temperature must be reached ahead of the solid-liquid interface. Because of the positive temperature gradient in the liquid this situation can only be realized if the liquidus temperature adjacent to the interface can be lowered compared to that of the bulk liquid.

Constitutional supercooling offers a means of achieving this decrease in the liquidus temperature, provided the concentration buildup at the interface and the temperature gradient in the liquid are appropriate as shown for curve D in Fig. 10.

Those conditions which reduce the length of the columnar zone and which were discussed previously assure a high degree of effectiveness of the added inoculants. Since grain growth control through alloying can be achieved with relatively small amounts of additions, one investigator[44] has attributed the restriction of grain growth by some small additions to copper as a "screening" action due to adsorption rather than constitutional supercooling.

It must be appreciated that grain refinement is possible through the introduction of suitable nuclei, by grain growth inhibition or by both means. Whether only one or both types of additions are necessary will depend upon whether the unmodified alloy does or does not already contain either a suitable inoculant or grain growth restricting agent. A shallow thermal gradient is also a definite aid to refinement, as demonstrated on work with aluminum.[51]

Peritectic Reaction Effectiveness

The effectiveness of the peritectic reaction in producing grain refinement has been recognized by a number of researchers.[46,51] In this reaction, the first crystals rejected from the melt are frequently rich in solute metal and provide effective nuclei for the succeeding low temperature phase. The latter phase is formed by interaction of the remaining liquid (usually the predominating constituent) and the primary crystals.

This reaction is diffusion controlled, slow and therefore acts as a grain growth inhibitor. In this manner the formation of a low concentration peritectic with the parent metal constitutes a separate method of grain refinement, since it provides both stable nuclei and grain growth inhibition. For aluminum it has

been found that a peritectic system[46] generally leads to grain refinement, while elements that formed a eutectic system with aluminum do not grain refine.

However, the observation that grain refinement in peritectic systems is dependent upon overheating is not compatible with the interpretation that the peritectic reaction itself is the important factor. For this reason objections to the above interpretation have been raised.[46,47,54] The difference of opinions which still persists on this matter must primarily be attributed to the difficulty of identifying the grain refining agents.

However, irrespective of which interpretation is correct the fact remains that alloying additions which form a peritectic with the parent metal at low concentrations can be successful in effectively refining certain metals.

Eutectic Grain Size Control

The control of grain or cell size in eutectics has also been investigated. Such additions as graphite, ferrosilicon containing aluminum and calcium, calcium-silicon, sulfur, calcium metal, calcium carbide and others[61-64] have been shown to reduce undercooling and refine the cell size of the austenite-graphite eutectic. This effect has been principally attributed to providing effective foreign nuclei for the solidification of the graphite phase in this anomalous eutectic.

This is substantiated by the fact that the above inoculants are most effective in the hypoeutectic irons and exert little influence on the solidification of the eutectic and hypereutectic types. The finer austenite-graphite eutectic cell and somewhat coarser graphite or secondary phase structure (which accompanies the slower solidification of this cell) generally improves mechanical properties although it may present other problems.

In contrast, better mechanical properties and longer feeding distances result with the aluminum—12 per cent silicon eutectic, if this anomalous eutectic solidifies from an uninoculated melt. In this condition, the formation of the eutectic structure is characterized by considerable undercooling, large cell size and a fine dispersion of the secondary silicon phase in the aluminum-rich primary phase.

This structure is attained by actual removal or poisoning of the potential effective nuclei for eutectic solidification. Such poisoning is accomplished by the addition of sodium metal or mixtures of sodium and potassium halide salts to the molten alloy prior to casting.[65]

SUMMARY

The solidification of molten metals is a phase change that occurs by a process of nucleation of stable crystal particles in the melt and the growth of these particles at the expense of the remaining liquid metal. Nearly every solidification starts at various preferred sites within the liquid at various degrees of undercooling below the melting or liquidus temperature. The rate of growth of these small crystals depends on the amount of undercooling before initiation of nucleation, the rate of heat removal from the remaining liquid and on the presence or absence of any barriers to rapid growth.

The basic principles of solidification apply equally well to pure metals, single-phase solid solutions and eutectics. Pure metals present a condition of least interference to growth of existing stable nuclei, and therefore usually exhibit a columnar structure to the center of the casting. Solid solutions frequently have an equiaxed zone, particularly in the more slowly solidified central portions.

The tendency toward equiaxed solidification is increased by a large freezing range (more mushy solidification) and large compositional variations between the liquid and solid phases to produce constitutional supercooling. Eutectics have a two-phase structure and occur in two varieties: the normal type in which one phase can serve as nuclei for the other phase resulting in a fixed orientation relationship between the two phases; and the anomalous type where independent nucleation of each phase is necessary and no regular orientation exists.

Since the as-cast grain size exerts a considerable influence on the properties of cast alloys, the control of this size and distribution is of commercial significance. The refinement of this grain size can be accomplished by rapid cooling, mechanical vibration or the introduction of foreign substances or special alloying additions to the melt. The selection of suitable additions to the melt depends on the mechanism of the refinement.

Materials added to become effective foreign nuclei or inoculants should have an appreciably higher melting point than the liquid metal, a similar density and permit nucleation with a minimum contact angle between the solid metal and inoculant. Additions intended to restrict grain growth should readily dissolve in the melt and provide a maximum solute concentration in the liquid melt immediately ahead of the liquid-solid interface.

The reduction of the thermal gradient in the liquid is desirable in either case because it assists in the nucleation of new grains within the melt proper. Peritectic reactions have been shown to provide effective grain refinement under appropriate conditions. If grain coarsening or undercooling is desirable poisoners can be added to the melt to remove effective foreign nuclei, as was accomplished in the aluminum-12 per cent silicon alloy.

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SOLIDIFICATION OF STEEL CASTINGS

by Charles W. Briggs

ABSTRACT

Contained herein is an up-to-date and extensive review of all the available literature on the subject of solidification of steel castings. The presentation begins with a discussion of the mode of solidification as related to the iron-carbon phase diagram and the start and end of freeze waves, and leads into the effects of such factors as mold materials, chills, gravity and convection, etc. A discussion of the solidification times for steel castings of various shapes follows.

INTRODUCTION

Extensive information is now available in the literature on the mode of the solidification of steel castings. However, this information is not being used to its greatest advantage, primarily because it is dispersed throughout the literature under various subjects, such as risering, chilling, shrinkage, etc.

This presentation is an attempt to collect and collate all the available literature on the solidification of steel castings. Unique aspects and characteristics of steel solidification are discussed, followed by comments concerning the factors affecting the solidification process and solidification times of steel castings. No direct mention is made of such related subjects as risering or gating of steel castings, or solidification of steel in ingot form.

Crystal Formation and Growth

The formation and growth of crystals are determined by the temperature distribution in the solidifying casting. The temperature distribution in the mold and the casting after a given time is illustrated in Fig. 1. This illustration shows that if molten metal is poured against a flat mold face heat will flow into the mold, and a solid layer of metal will be deposited at the mold-metal interface.

The thickness of this layer will increase with time as heat continues to flow outward. The temperature of the boundary between liquid and solid metal is, of course, the freezing point of the metal, and heat of solidification is liberated at this boundary. The rate at which the boundary moves is determined by how rapidly the heat of fusion is removed.

The first stage in the solidification of a casting is the formation of a thin chill layer, owing to the low temperature of the mold. The chill layer usually possesses a finely grained structure caused by the rapid cooling and large number of nuclei which form. The chill layer, however, may entirely or partially disappear when hot steel is used or when the mold is heated, reducing the chilling action of the mold. Dendrites start to grow from the inner boundary of the chill layer toward the thermal center of the mold.

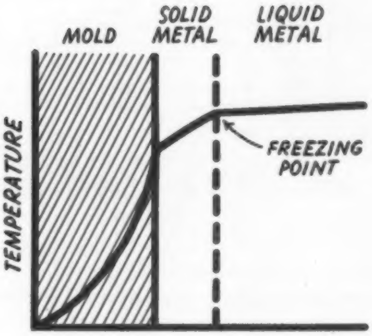

Fig. 1—Temperature distribution showing heat flow during unidirectional solidification of a pure metal from a flat mold wall.

The resultant crystals will necessarily be elongated or columnar under usual conditions, for dendritic growth is preferential in the direction of the temperature gradient. Their direction thus indicates the direction in which a casting solidifies. As the growing columnar crystals approach the interior of the casting, the thermal gradient is diminished by the dissipation of superheat. This enables other crystals to nucleate at random rather than having continued growth take place at the tips of the columnar grains. This process is illustrated schematically in Fig. 2.

Freezing Temperature Range

Commercial metals, in general, do not freeze at a definite, fixed melting point. Rather, they freeze over a range of temperatures which can be predicted from the phase diagram for the particular metal. Figure 3 illustrates schematically the relationship between the iron-carbon phase diagram and the mode of solidification of a 0.30 per cent carbon steel casting.

This diagram shows that because of thermal gradients which are active in the solidification of a casting from a mold wall there may exist:

1) A completely solid zone.
2) A zone consisting of solid dendrites with liquid metal at the dendrite interstices.
3) A completely liquid zone.

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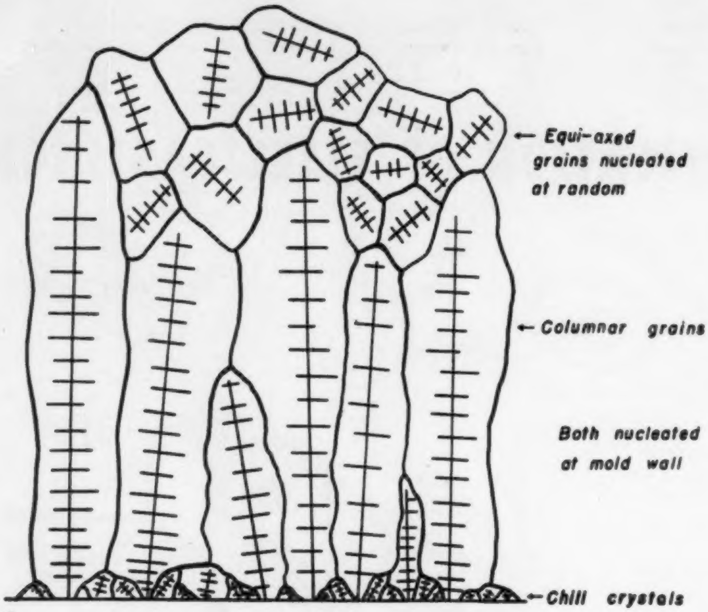


Fig. 2 — Schematic drawing of a cross section through a casting.

At least two and often three of these zones exist concurrently during the wall growth of a casting, depending upon the type of metal, the mold material and stage of solidification.

Wall growth may be visualized as occurring by the travel of two waves, the "start of freeze" and "end of freeze" waves, from the mold-metal interface to the casting center line. The start of freeze wave travels with the tips of the growing dendrites into free liquid and indicates the beginning of solidification. The end of freeze wave travels with the base of the growing dendrites where the last remaining liquid solidifies. The space separation between the two waves consists of intermixed liquid and solid metal and is the zone where actual solidification occurs.

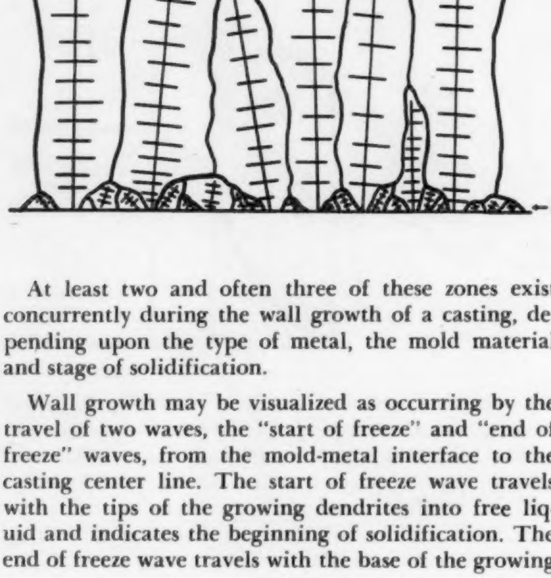


Fig. 3 — Diagram showing the relationship between the iron-carbon phase diagram and mode of solidification of a 0.30 per cent carbon steel casting.

The rates of travel of the start and end of freeze waves and their space separation within the casting vary with the mold materials and the type of metal undergoing solidification. Basically, these variations arise from the difference in thermal properties of both the mold and solidifying metal which govern the manner and rate of heat transfer. A typical start and end of freeze wave diagram is shown in Fig. 4. This illustrates the mode of solidification of a 0.25 to 0.30 per cent carbon steel in green sand and chill molds.

CHARACTERISTICS OF STEEL SOLIDIFICATION

Volume Changes During Solidification

The most obvious characteristic of the solidification process is the contraction or change in volume of the solidifying steel. This decrease in volume is an inherent characteristic of many solidifying metals. The total contraction of a steel casting is the sum of three stages:

1) Liquid contraction.
2) Solidification contraction.
3) Solid contraction.

Figure 5 is a typical cooling curve for a carbon steel cooling from 1750 C (3182 F) to room temperature.

Total contraction has been found to increase with an increase in carbon content. What appears to be the most authoritative work on the subject[3] shows the change in specific volume of a 0.35 per cent carbon steel, expressed in terms of volume contraction at room temperature, to be 1.6 per cent per 100 C or

0.89 per cent per 100 F. This value is slightly diminished by an increase of chromium and aluminum and increased by greater amounts of carbon, silicon, manganese and phosphorus.

However, for the usual cast carbon steels and low-alloy cast steels, the liquid contraction may be considered to be about 1.50 to 1.75 per cent of its volume at room temperature per 100 C. This value is shown in Fig. 5 in conjunction with solidification contraction and solid contraction.

Steel also contracts upon solidifying, i.e., as it passes through the two-phase (liquid plus solid region) and finally becomes completely solid. The various volume contraction figures which are available show an average of 0.0039 cc/gram for a 0.35 per cent carbon steel, which is equivalent to 2.85 per cent of the specific volume of the solid steel at the freezing point – or 3.05 per cent of the specific volume at room temperature.

There are no accurate measurements available of the effect on the solidifying contraction of such differences as may be encountered in the carbon and alloy contents in steels. However, it is believed that there would be but little change in the value with increasing carbon content since the specific volume of both liquid steel and solid steel increases as the carbon content is increased. Experimental evidence tends to show that pure iron exhibits a solidifying contraction of about 2.2 per cent. This value increased to approximately 4 per cent for that of a 1.00 per cent carbon steel.

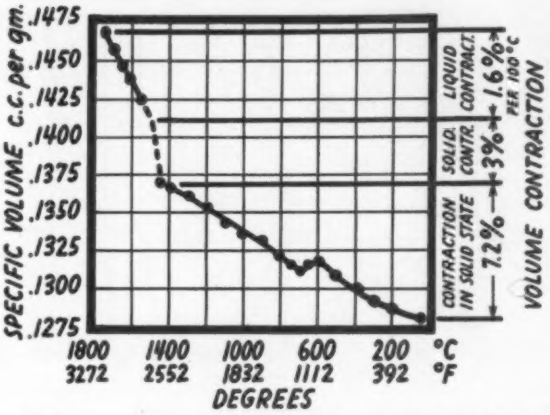


Fig. 5 — Volume change recorded on cooling of a 0.35 per cent carbon cast steel. (Briggs and Gezelius)[2]

Equilibrium Phase Diagram

The iron-carbon phase diagram showing the liquidus and solidus curves is presented in Fig. 6. It is noted that increased carbon content tends to lower both the solidus and liquidus and enlarge the freezing range. Slightly below and roughly paralleling these curves appear the liquidus and solidus curves which were obtained by a study of the melting and freezing temperatures of steel for commercial steel castings. In general, the curves for the commercial steel are situated about 20 to 25 F below those of the iron-carbon system. However, the peritectic transformation occurring at 2718 F (1492.4 C) does not appear to be altered in commercial cast steels.

A study[4] of the melting and freezing points of a number of commercial steels led to the conclusion that the liquidus and solidus curves of commercial carbon steels conform with the iron-carbon diagram with respect to carbon content and temperature, provided that the manganese content is below 0.45 per cent and the silicon below 0.35 per cent. However, if manganese and silicon contents are raised, the liquidus and solidus temperatures are lowered. The dotted lines on the phase diagram of Fig. 6 hold in general for steel castings of nickel and chromium content up to one per cent.

The diagram of Fig. 6 can be used to predict the freezing history of a steel cooled under equilibrium conditions. A 0.30 per cent carbon commercial steel, for example, begins to freeze at 2740 F (1504.4 C) with the formation of delta iron in the melt. At 2718 F (1492.4 C) the steel will traverse the peritectic transformation and austenite will proceed to form directly from the melt. When the temperature drops to 2650 F (1454.4 C), the solidus is reached and freezing is complete.

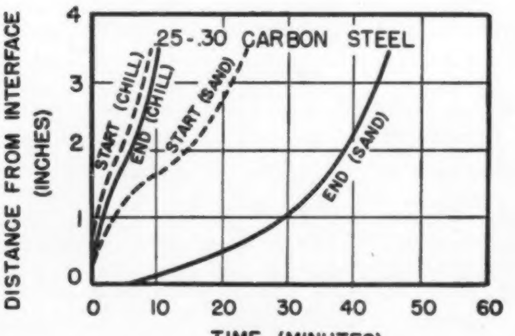


Fig. 4 — Start and end of freeze wave diagram for a 0.25 - 0.30 per cent carbon steel cast in a green sand and chill mold. Casting cross-section 7 in. Pouring temperature 2800 F. Sand thickness 7 in. Mold chill thickness 7⅛-in. (Bishop and Pellini)[1]

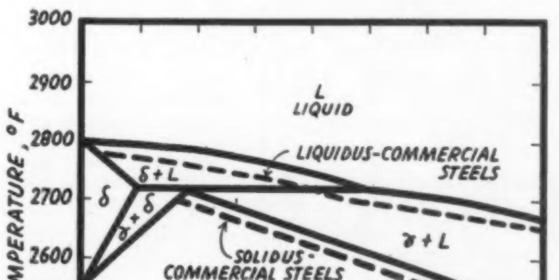


Fig. 6 — The iron-carbon phase diagram.

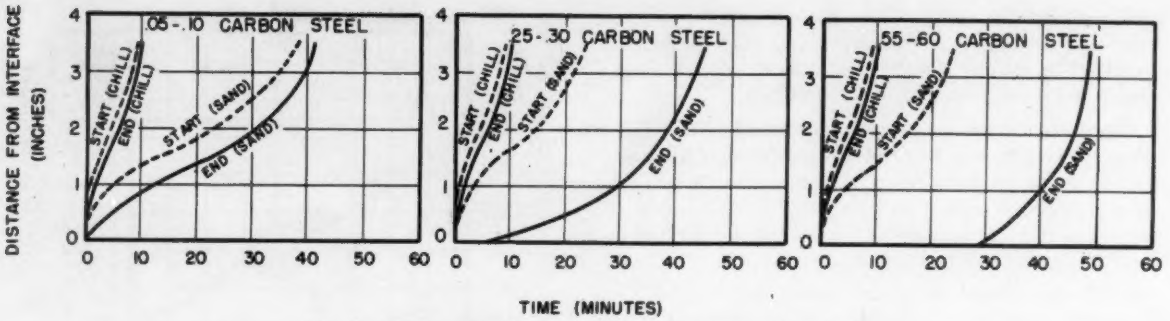


Fig. 7 — Effect of carbon content on the start and end of freeze waves in sand and chill molds. (Bishop and Pellini)[1]

Temperature Level and Temperature Range of Solidification

The equilibrium diagram of Fig. 6 reveals a factor which has a significant influence on the mode of solidification of steel, specifically, the temperature level at which solidification occurs. Temperature gradients which are established between the solidifying metal and the mold wall are a function of the difference between the temperature of the metal and the temperature of the mold. The high solidification temperature of steel means a large temperature difference and thus steep thermal gradients which result in a high degree of progressive solidification.

The temperature range over which a metal solidifies, that is, in which liquid and solid phases coexist, is also an important factor in determining the mode of solidification. Steels containing 0.08, 0.25 and 0.60 per cent carbon have been determined to solidify over a temperature range of 40, 75 and 125 F, (4.4, 23.9 and 51.7 C) respectively.

Given the same properties of the metal and the mold (and thus essentially the same temperature gradients) the steel with the narrowest solidification range will exhibit the highest degree of progressive solidification, since the gradients intercept the liquidus and solidus temperatures at more closely spaced locations. Thus, one would expect solidification to be highly progressive in a low carbon steel and much less progressive in medium and high carbon steels. This is indeed the case, as may be seen in Fig. 7. However, in all instances, the solidification is much more progressive than in non-ferrous metals.

Thermal Conductivity of Mold and Solidifying Metal

The mode of solidification of a metal is a function of the thermal gradients established during freezing, therefore, the thermal properties of both mold and metal solidifying must be considered as important factors in the determination of the nature of steel solidification. A mold made of a material having a high thermal conductivity and a high heat capacity, such as a chill mold, will absorb heat quickly and over an extended period of time.

A high conductivity also results in a rapid flow of heat away from the mold-metal interface, which causes the interface of the solidifying metal and the mold to be maintained at relatively low temperatures. The low interface temperature means that steep thermal gradients will be established (Fig. 8a), and concomi-

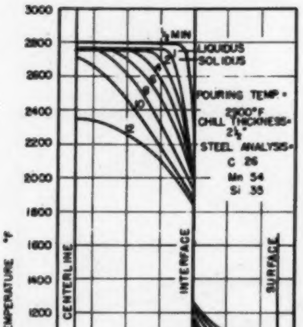
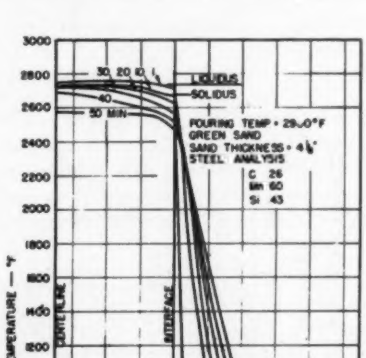


Fig. 8 — Thermal gradients in steel castings and in the mold; (A) 2½-in. thick chill used, (B) green sand — no chill. (Bishop and Pellini)[1] A (left); B (right).



tantly solidification will be of a highly progressive nature.

The mode of solidification of metal in a sand mold will be quite different from that in a chill mold, due to the low thermal conductivity and low heat capacity. Sand, a good insulator, is able to absorb little heat and is also unable to conduct heat away from the mold-metal interface at any appreciable rate. For this reason, the temperature of the sand at the casting interface approaches rapidly the temperature of the solidifying metal (Fig. 8b) and only mild temperature gradients are established in the metal. Thus, metal poured into a sand mold will solidify in a much less progressive manner than in a chill mold.

The thermal conductivity of the freezing metal also exerts an appreciable effect on the thermal gradients established during solidification. A metal having a high conductivity will allow heat to be carried from the center of the solidifying section to the mold-metal interface rapidly. Thus, heat removed by the mold from the casting surface will quickly be replaced by heat from the interior, and only mild gradients can exist within the freezing metal causing poorly progressive solidification.

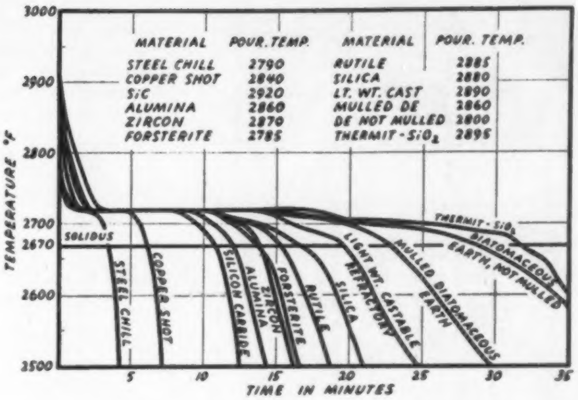
Heat flow within a solidifying metal having a low thermal conductivity is sluggish, thus allowing steep gradients to be formed and maintained, and solidification will be of a more progressive nature. Steel is a metal having a relatively low thermal conductivity, and this is one of the factors that aid in producing progressive solidification in the carbon grades having a wide temperature range of solidification. It should be pointed out that the effect of metal conductivity is minimized in a sand mold due to the low thermal conductivity of the sand.

FACTORS AFFECTING THE SOLIDIFICATION OF STEEL

Mold Material Effect

The mold material affects the mode of solidification of a steel casting primarily by its ability to extract heat. The greater the heat extracting ability of the mold material, the greater will be the advance of the start and end of freeze waves through the casting. A knowledge of the heat extracting ability of a molding material is essential to the practical foundryman interested in applying controlled directional solidification to produce castings free from internal cavities. A common application of this knowledge is in the use of metal chills to increase the rate of solidification at a point distant from a riser, or the use of insulating sleeves around a riser to decrease the rate of solidification.

The author's company[5,6] has investigated the chilling ability of various molding materials with the aim of finding materials which might be used as moldable chills or insulators. Cooling curves for the various materials tested are shown in Figs. 9a and 9b. A graphical comparison of the chilling ability of the various molding materials corrected to a standard pouring temperature of 2870 F (1576.7 C) is presented in Fig. 10.



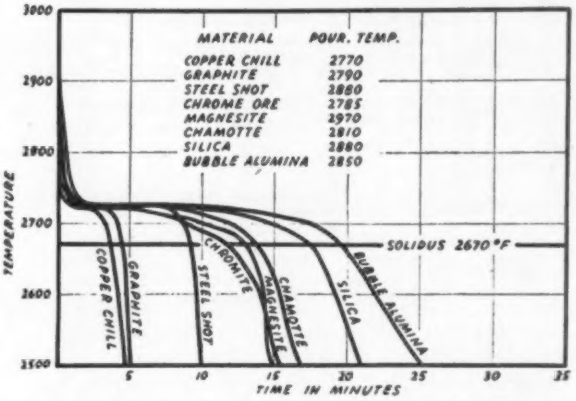


Fig. 9 — Cooling curves at the center of a 6-in. sphere produced in various molds. (Locke, Briggs, and Ashbrook)[6]

Metal Chills Effect

The preceding discussion has shown that the most effective means of extracting heat from a solidifying casting is through the use of a metal chill. Previous curves (Fig. 7) have shown the effect of a chill mold in the progression of start and end of freeze waves from the walls of a 7-in. block-type casting. It was shown that a steel casting in a metal mold would complete its solidification in 20 to 25 per cent of the time required for the same casting in a sand mold.

Figure 11 shows the advance of the end of freeze waves in 2-in. thick plates and 4-in. thick bars in both the end-chilled and unchilled conditions. The bars were 4 x 4 in., and the plates had a width equal to 5 times their thickness. The chill is seen to have a great effect upon the end of freeze wave, especially during the early stages of solidification. In addition to aiding directional solidification, several investigations[8,9,10] have shown the use of external chills to be highly beneficial to mechanical properties.

Chill thickness was found to have only a slight effect upon the solidification process as may be seen in Fig. 12. This figure shows that little is to be gained by going to larger chills. Studies on the thickness of chills to be employed show that chills are fully effective for a bar when the chill thickness is equal to half the thickness of the casting (½T) and that 1T chills are similarly adequate for plates.

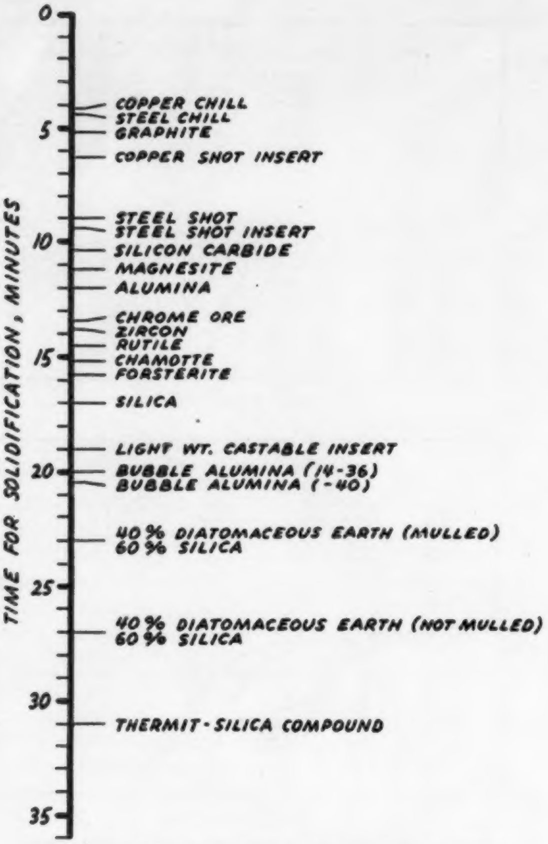


Fig. 10 — Effect of various molding materials on solidification time of 6-in. spheres.

Chills of larger thicknesses are overadequate. They absorb added heat from the interface regions, but this added heat is primarily specific heat from the solid metal rather than heat of fusion. For this same reason, high-conductivity copper and water-cooled chills do not cause a measurable improvement in casting soundness over that attainable with steel or cast iron chills.

Gravity and Convection Effect

Gravity and convection effects on the solidification of steel have been given little consideration in the American literature. The British, however, have investigated these effects, and a summary of their results[12,13,14,15] is presented.

Gravity and convection have their greatest effect upon the macrostructure of the casting. This effect has been explained in terms of the "falling crystallite" theory. In essence, this theory states that minute embryos or crystallites form in the melt as the melt reaches the liquidus temperature, and, if conditions are right, these crystallites will fall to the lower portions of the casting.

Three types of crystals are recognized:

1) columnar, which are the long thin grains.
2) equiaxial, which are grains that are not elongated in any single direction, yet show evidence of internal dendritic formation.
3) nuclear, which are small units which have developed by growth from a large number of nuclei, and which do not show internal dendritic formation as may be evident in the larger equiaxial crystals.

Several interrelated factors come into play in determining the extent of the effect of gravity and convection upon the mode of solidification. Among these factors are superheat, chilling effect of the mold material, riser size and thermal gradients in the casting.

Macrostructure Differences

The difference in the macrostructures of the two bar castings shown in Fig. 13 were explained[13] in terms of the falling crystallite theory. These two castings were poured in the same mold from a common downsprue and bottom gate. They both had exothermic sleeves around the 6-in. riser. The only difference was that *b* also had extothermic powder sprinkled on the riser surface in order to increase the riser life. Quite a difference is shown in the two macrostructures.

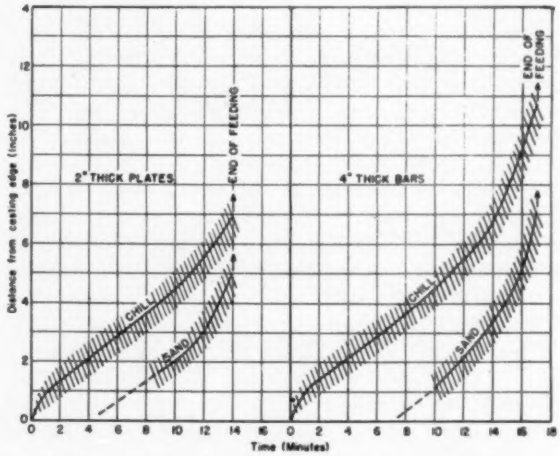


Fig. 11 — Progression of the end of freeze wave from the extremities of chilled and unchilled plates (left) and bars (right). (Myskowski, Bishop and Pellini)[7]

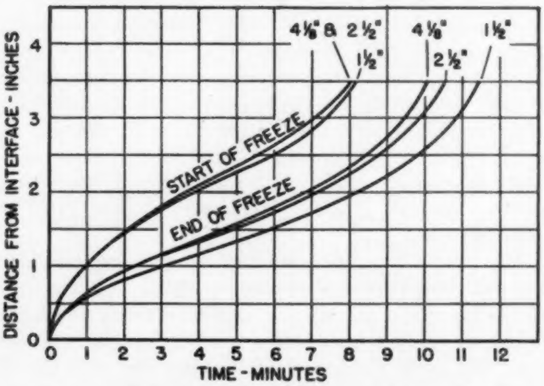


Fig. 12 — The effect of chill thickness in the progressive solidification of a 7 x 7-in. section steel casting. Pouring temperature 2800 F; carbon content 0.60 per cent; cast iron chill. (Bishop, Brandt and Pellini)[11]

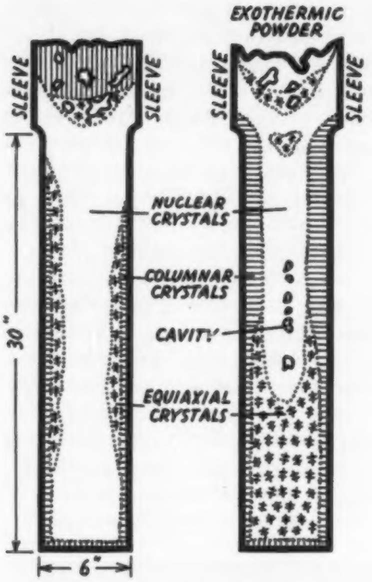


Fig. 13 — Schematic diagram showing macrostructures of two bar castings poured in the same mold from a common runner. 0.35 per cent carbon steel; dry sand mold. (Gray)[13]

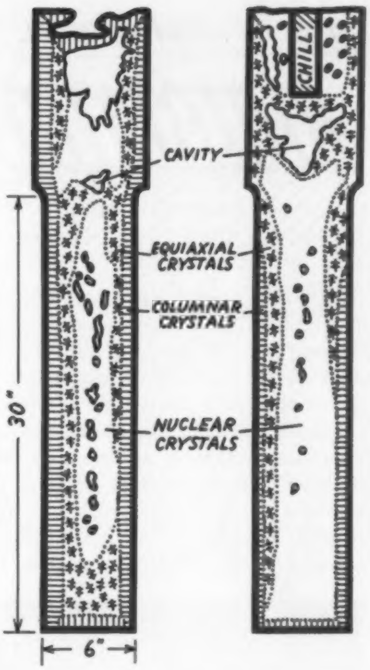


Fig. 14 — Schematic diagram showing macrostructures of two bar castings poured in the same mold from a common runner. 0.35 per cent carbon steel; dry sand mold. (Gray)[13]

Casting *a* was found to have nuclear crystals to a much greater depth than casting *b*. Theoretically, solid nuclei form more readily at the top of casting *a* than casting *b*. In each case, these nuclei, being more dense than the surrounding liquid, begin to fall towards the bottom of the casting. Aided by a greater thermal gradient (hence greater convection currents in the liquid) between the top and the bottom of casting *a*, the nuclei are able to fall more readily and to a greater depth, as shown. The difference in the macrostructures of the castings shown in Fig. 14 was explained in the same manner.

These bar castings are similar to those of Fig. 13, except for the larger risers. These also were poured in the same mold from a common downsprue. The only difference is that the riser of casting *b* was heavily chilled by the insertion of five iron bars. Again more nuclear crystals found their way to the bottom of the casting which had the greater thermal gradient and hence the greater convection currents between the top and bottom.

Figure 15 shows the results of another investigation.[12] The only difference between the castings of Fig. 15a and 15b was that 15b had a larger riser and one lb of exothermic material was sprinkled on top. A great difference is seen in the macrostructures. Casting *a*, with the greater thermal gradients between the top and bottom is seen to be almost wholly composed of nuclear crystals, while casting *b* is composed only of equiaxial and columnar grains.

This same investigation showed that in a casting containing both nuclear and equiaxial or columnar grains, the portions of the casting containing the nuclear grains were purer chemically (i.e., contained less alloying elements) and possessed better tensile properties.

Gravity and Convection Effect

There appears to be some practical aspects relative to the effect of gravity and convection currents. The investigations described above show that gravity and convection effects play a part in producing a finer grained structure in the casting. It was shown that in order to induce these effects, it is necessary to have more rapid cooling at the topmost portions of the casting in order that crystallites might form early and then fall into the liquid below.

This, however, is not in accord with the principles of directional solidification, which must be observed if sound castings are to be produced. Considerable success has recently been met in efforts to change the mode of crystal formation of cast steel by the use of an inoculant, i.e., a substance which, when added to the molten steel, will induce the formation of a large number of solid nuclei. This opens the possibility of using gravity and convection effects in conjunction with an inoculant to produce a small crystal structure throughout the casting. The inoculant would necessarily be iron alloy powder or alloy carbide powder.

Solidification in a Flowing Stream

Pouring time is usually relatively short in comparison with freezing time, and often pouring is

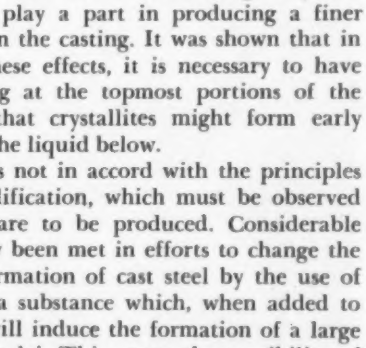


Fig. 15 — Schematic diagram showing macrostructures of two bar castings. Pouring temperature 2833 F; 0.40 per cent carbon steel. (Samways)[12]

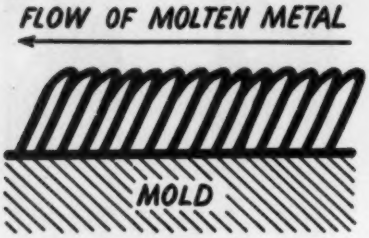


Fig. 16 — Schematic diagram showing the grain structure in a flowing stream.

complete before solidification begins. In such cases casting solidification generally progresses into a non-flowing pool of liquid metal. However, in some cases such as thin-sectioned castings, solidification begins before the mold cavity is completely filled.

Figure 16 illustrates schematically the nature of the structure obtained as steel solidifies in a flowing stream. It is of interest to note that the columnar crystals point "upstream," i.e., into the oncoming liquid. This angle of tilt is related[16] to the flow velocity of the liquid, a greater angle of tilt being associated with a greater flow velocity. In addition, the flowing stream promotes the growth of columnar crystals in preference to equiaxial grains.

An investigation of the mode of solidification in a thin section has been made.[17] The standard fluidity spiral was the section studied. Figure 17 illustrates a typical crystal structure observed in a 0.21 per cent carbon steel at various distances from the downsprue of this casting. The investigation showed that the higher the pouring temperature, the larger the columnar crystals. The length and the angle of slope of the columnar crystals were found in all cases to decrease with increasing distance from the downsprue.

Additional evidence indicated that the position at which this thin section first solidified completely was related to the pouring temperature, a high superheat promoting solidification first near the sprue and low superheat promoting solidification first at the tip.

This aspect of solidification in a flowing stream becomes increasingly important as consideration is given to thinner and thinner sections. High pouring

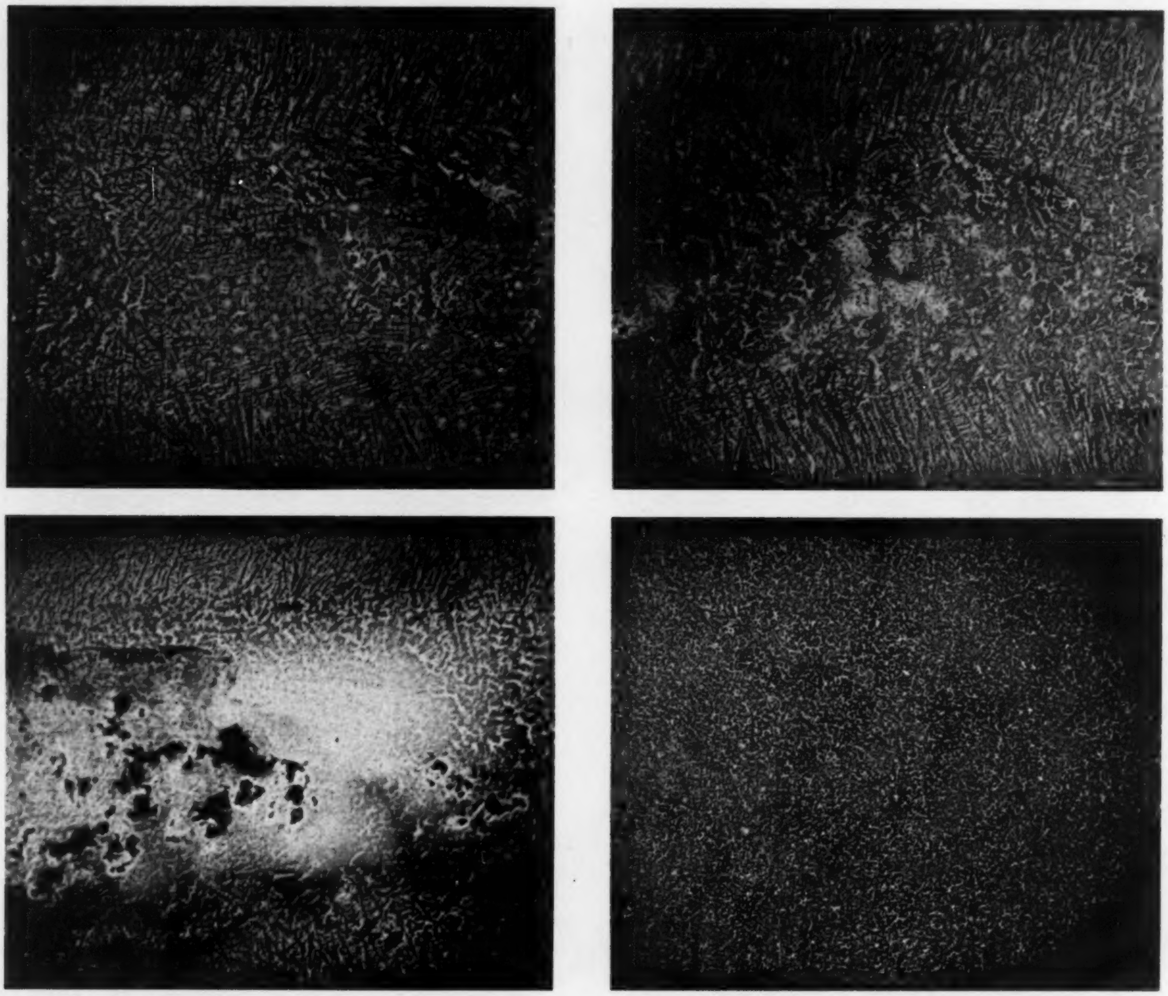


Fig. 17 — Grain structure observed at various positions in the standard fluidity spiral. 0.21 per cent carbon steel; pouring temperature 2900 F; spiral length 15 in.; spiral cut lengthwise perpendicular to parting line; magnification 8½ ×; (a) adjacent to sprue, (b) 5 in. from sprue, (c) 10 in. from sprue and (d) 15 in. from sprue. Flow is from left to right. (Rowe)[17] Top row — a (left), b (right); bottom row — c (left), d (right).

temperatures are needed in order to run thin sections, yet these high pouring temperatures promote longer columnar crystals which converge towards the centerline to choke off the metal flow.

Other Factors Affecting the Solidification Process

Other factors, such as mold thickness, superheat and sand moisture, also affect the mode of solidification of steel castings. These effects are summarized in Figure 18.

Figure 18a shows the effect of increasing the sand mold wall thickness from 2½ to 7 in. on the solidification of a 7 x 7-in. section steel casting. The effect is one of a general delay in the solidification with increasing sand thickness. The reason for the faster solidification in the case of the thinner mold walls is that the steel flask acts as a chill and becomes effective before the casting solidifies. The solidification time is increased 10 per cent when the mold wall is increased from 2½ to 4⅛-in.

A further increase from a 4⅛ to a 7-in. thick mold only increases the solidification time 2 per cent. It would appear from this that approximately a 4-in. mold wall is sufficient thickness for a 7 x 7-in. section. It has been reported[18] that a sufficient sand wall surrounding the casting should be 1.4T. Sand thickness greater than this does not contribute to the solidification characteristics of the casting.

Figure 18b illustrates the effect of pouring temperature variations on the solidification of a 7 x 7-in. section steel casting in a sand mold. A higher superheat is seen to delay the start of freezing of the steel somewhat. This delay is caused by the liberation of the additional heat resulting from pouring the higher temperature steel. Superheat also increases the solidification interval; however, the rates of travel of the various end of freeze curves are approximately the same.

Figure 18c shows the effect of a dry sand mold, as compared to one containing 3 per cent moisture, on the progressive solidification of a 7 x 7-in. section. The presence of moisture speeds up solidification during the initial stages and causes the development of the end of freeze wave to occur earlier. This effect is apparently lost during the later stages of solidification, as is indicated by the merging of the green and dry sand curves. This is additional proof of the well-known fact that steel castings in green and dry sand molds solidify in a similar manner.

SOLIDIFICATION TIMES FOR VARIOUS SHAPES

The rate of solidification and solidification time of steel castings are primarily determined by the thermal properties of the mold, composition of the steel, pouring temperature, section size and casting configuration. The first three variables in this list are discussed in other parts of this report, and no further elaboration will be made on them in this section.

Solidification Calculations

The solidification of steel in metal molds has been studied theoretically, and it was determined that the rate of solidification of steel could be expressed as a parabolic function:

$$D = K\sqrt{t}$$

Here D is the thickness frozen in time t, and K is a constant of solidification.

Attempts have been made to fit this formula to experimental data on steel cast in sand molds, but it was found that the equation could be used successfully only in the early portion of the solidification of a section. The data appeared to fall on a hyperbolic rather than a parabolic curve, but a fairly good fit was obtained using the general equation

$$D = K_1 t^{0.4} + K_2 t$$

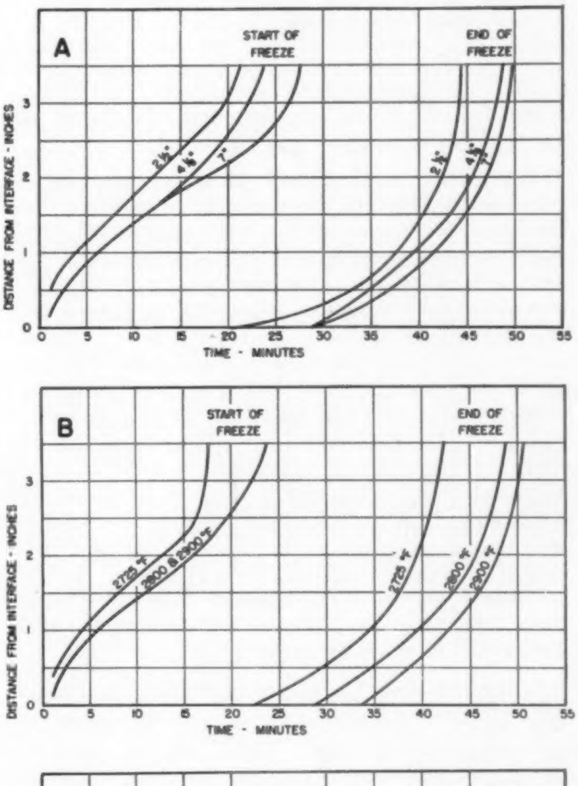


Fig. 18 — Progress of solidification of a 7-in. square casting. (A) green sand mold thickness series, pouring temperature 2800 F; (B) green sand superheat series, mold thickness 4⅛-in.; (C) comparison between green and dry sand, mold thickness 4⅛-in., pouring temperature 2800 F. (Bishop, Brandt, and Pellini)[11]

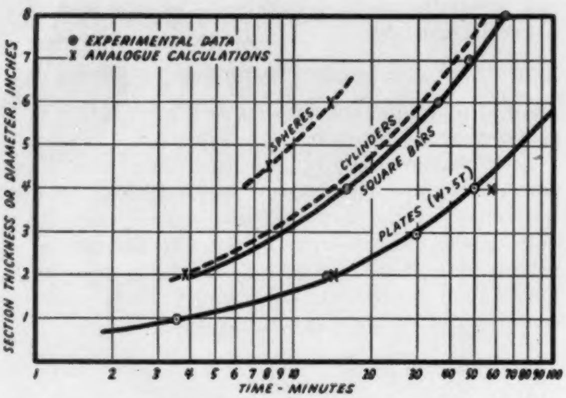


Fig. 19 — Solidification times for various shapes of steel castings in sand molds.

where K_1 and K_2 are constants depending upon the shape of the mold, etc.

The earliest and most well-known relationship between solidification time and casting geometry was developed by N. Chvorinov.[19] He suggested that the time required for complete solidification of a steel casting is proportional to the square of the casting volume divided by the square of the surface area of the casting, that is:

$$t_f = \frac{1}{K^2}\left(\frac{V}{SA}\right)^2 \times 60$$

where:

t_f = freezing time in min.
V = casting volume in cu in.
SA = casting surface area in sq in.
K = constant.

For spheres, cylinders and plates, K has been found to be 2.09, while for bars and rectangles it has been determined to be 1.92.

While this equation is not completely rigorous, it does represent an excellent engineering approximation. However, it should be pointed out that the relationship does not take into consideration the solidification shrinkage, and thus it can not be applied to the dimensioning of risers.

Fig. 20 — Progression of end of freeze wave contour in solidifying *L* and *T* sections. (Brandt, Bishop, and Pellini)[25]

Application of the equation to simple shapes such as plates, bars and cylinders, must be on the basis that no (little) heat flows from the edges of plates or the ends of long bars or cylinders. A heat flow from these edges (such as exists in thick plates) will affect the volume to surface area ratio of the above equation. The volume/surface area relationships for various shapes are as follows:

Shape	V	SA	V/SA
Large Plate	LWT	2LW	T/2
Long Bar	LT^2	4LT	T/4
Cube	T^3	$6T^2$	T/6
Long Cylinder	$\pi L D^2/4$	πDL	D/4
Sphere	$\pi D^3/6$	πD^2	D/6

Solidification of Simple Shapes

Most of the thermal studies on progressive solidification of cast steel have been carried out on 4 x 4, 6 x 6, 7 x 7, and 8 x 8-in. cross-sections.[11,20,21,22] In such castings, progressive solidification proceeds equally from all four faces. The data obtained have been plotted in Fig. 19, and a curve for square bars has been constructed.

Plates solidify progressively from only two faces. Therefore, the solidification time for a plate of the same thickness as a bar is delayed. In fact, a bar with a 4 x 4-in. cross-section solidifies in 16 min, whereas a plate 4 in. thick requires approximately 50 min to solidify.

Calculations on the solidification time of cylinders and plates by the electric analogy method[23,24] are also shown as points on the graph.

Solidification at Corner Positions

The mode of solidification is determined by heat transfer, and thus growth of walls from which heat is being extracted at unequal rates must be considered. This is the type of freezing encountered in *L* and *T* sections. The unequal rates of heat extraction from the walls of the junction have two notable effects on solidification, i.e., the thermal center of the junction is displaced from the geometric center and the time of final solidification is changed.

A study was made of *L* and *T* junctions of 4-in. sections poured in 0.25 carbon steel.[25] Figure 20 shows the solidification conditions in these sections at various times during the course of freezing. It may be seen that the rate of wall buildup is most rapid at the external corner of the *L* section and slowest at the internal corner, while solidification from the flat surface of the plate progresses at an intermediate rate.

The reason for this is that the heat flow paths from the external corner are divergent, and for the internal

core they are convergent while they are parallel to the flat surface. As the heat flow paths move from a divergent to a convergent position, heat is conducted to a steadily decreasing mold area and the time required for final solidification increases.

It should be noted that the position of a shrinkage cavity is not the position of final solidification. Due to the effect of gravity, the last metal to solidify drains to the bottom of the hot spot region, and thus the shrinkage cavity will be located directly above the last part of the section to freeze.

The previously discussed conditions have been known by the steel casting industry for some time. Thus sharp internal corners are never used, but rather a radius of T/3 is used when the member section thickness (T) is greater than 3 in. Such a radius would permit a solid skin to be formed early in the solidification cycle of the section rather than in 50 min, as shown in Fig. 20.

The relative solidification times of a 4-in. thick flat plate and 4-in. *L* and *T* sections are 48, 62 and 72 min, respectively. Thus it is seen that adjustment factors of 1⅓ and 1½ should be used for flat plate sections joined in *L* and *T* designs when calculating the solidification time of such sections from the volume-surface area relationships of the flat plate.

Solidification at Core Positions

The nature of solidification in bushings having a 4-in. wall thickness has been studied[25] to determine the effect of cores on freezing rate and solidification time. Castings were made using cores of 2, 4, 8 and 16-in. diameters. The results of the thermal analyses made showed that with a 2-in. core the thermal gradients over the entire section slope toward the outer surface of the casting after about 30 min. This indicates that at this time essentially all of the heat is flowing from the casting into the mold wall.

The same conditions were found to characterize the casting with the 4-in. diameter core after 60 min from the time of pouring. This appears to be the borderline case in which the core stops removing heat just shortly before the end of freeze wave reaches the core surface. The 8 and 16-in. diameter cores were found to extract heat throughout the entire period of solidification. However, near the end of solidification, the gradients in the metal adjacent to the mold wall are steeper than those in the metal adjacent to the core, which indicates that a larger amount of heat is being extracted by the mold than by the core.

Figure 21 shows the progress of the end of freeze waves across the 4 in. wall section of the various test castings. Data for a 4 in. thick flat plate (representing the case of infinitely large core diameter) and for an 8 in. diameter cylinder (representing the case of an infinitely small core diameter) are included for comparison purposes. It may be observed from the curves that as the core diameter increases, the solidification pattern moves towards the symmetrical characteristics

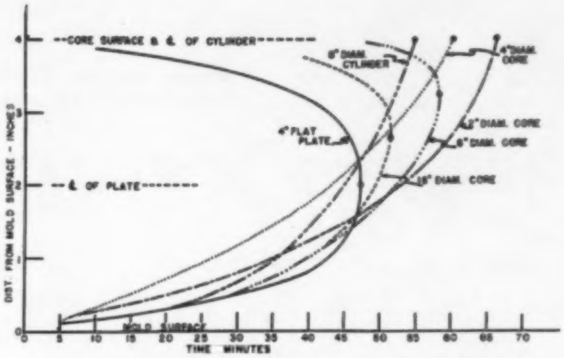


Fig. 21 — Progression of end of freeze waves in cored cylinder castings. (Brandt, Bishop, and Pellini)[25]

of the flat plate, and the thermal center approaches the geometric center of the 4 in. wall.

However, with a 16 in. diameter core, the thermal center is still approximately ½-in. from the geometric center. For the 8 in. diameter core, the thermal center is located approximately 1¼-in. from the geometric center, while for 4 and 2 in. diameter cores the thermal center is at the core-metal interface, i.e., the metal adjacent to the core is the last metal to solidify.

Figure 22 shows a plot of the time required for complete solidification vs. core diameter for all of the test castings poured. It also indicates the effective volume to surface area ratios which should be used in the calculation of freezing times for various casting configurations. However, as a practical approximation for calculation of freezing times, bushings having core diameters greater than twice the wall thickness may be considered to solidify essentially as a flat plate of equivalent wall thickness. Bushings with core diameters less than twice the wall thickness may be considered to solidify essentially as cylinders of radius equal to the wall thickness.

SUMMARY

A knowledge of the fundamentals of solidification of steel castings is an essential foundation for the consideration of the related topics of gating, risering and directional solidification. This presentation reviews and summarizes the work of many investigators in sufficient detail to provide a sound engineering understanding of the principles involved in the solidification of steel castings.

The solidification of steel is of a progressive nature with growth toward the thermal center of casting section. The degree to which solidification is progressive is determined by steel composition, thermal properties of the mold, temperature level of solidification and solidification range.

The effect of various molding materials and chills is to alter the time of solidification of the casting. Gravity and convection produce fine macrostructures, whereas the flow of metal over a solidifying face produces a coarser macrostructure. Superheat and mold thickness have only a slight effect upon the mode of solidification.

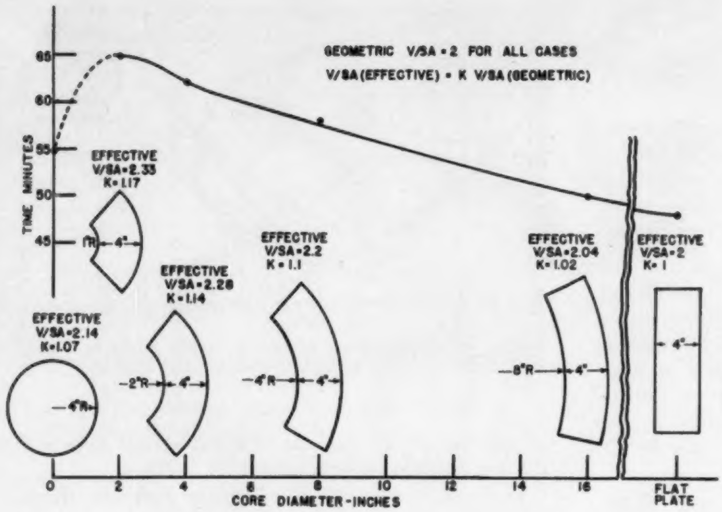


Fig. 22 — Relation of solidification time to core diameter. (Brandt, Bishop, and Pellini)[25]

The rate of solidification is shown to be slower at internal corners and core surfaces than at external corners and flat mold faces. The time required for complete solidification may be presented by the equation known as Chvorinov's rule:

$$t_f = \frac{1}{K^2}\left(\frac{V}{SA}\right)^2$$

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SOLIDIFICATION OF CAST IRON

by C. K. Donoho

ABSTRACT

Consideration is given to solidification of hypereutectic and hypoeutectic cast irons, dealing with white, gray and ductile iron. The important features of the solidification process of these cast irons, as well as carbon equivalent calculation formulas, are presented.

GENERAL

The family of cast irons is distinguished from other ferrous metals in that cast irons contain sufficient carbon so that the last metal to freeze is always of eutectic composition. With pure iron carbon alloys, this means that the carbon content must be greater than about 1.98 per cent C. Other elements, such as silicon and phosphorus, reduce the amount of carbon required to reach eutectic composition during freezing.

The solidification of cast iron occurs over a range of temperatures, except in the unique case where the metal is exactly of eutectic composition. Eutectic irons solidify at nearly a constant temperature, although, alloys and impurities may often cause some range of solidification even with eutectic composition.

In pure iron carbon alloys, the eutectic composition is variously estimated at 4.23 per cent to 4.30 per cent carbon. Silicon and phosphorus especially lower the carbon required to reach eutectic composition. The normal iron carbon diagram may be used for irons containing silicon and phosphorus, if, instead of carbon content, a carbon equivalent or CE figure is used. Various formulas have been proposed to calculate CE values for cast iron. Commonly used in America are:

$$CE = \text{Tot. C} + \tfrac{1}{3}\,(Si + P)$$

$$CE = \text{Tot. C} + 0.3\,(Si + P)$$

Using this, a CE value of 4.3 is taken as the eutectic. A possibly more exact and general formula frequently given in European literature is:

$$CE = \text{Tot. C} + 0.312\ Si + 0.33\ P - 0.078\ (Mn - 1.8\ S)$$

With this formula, 4.23 per cent is assumed to be the eutectic composition. In the usual cast iron compositions, either of these formulas will give values sufficiently accurate for practical estimation.

The solidification mechanism of any cast iron depends in a fundamental manner on whether the metal is hypoeutectic, eutectic, or hypereutectic.

WHITE IRON SOLIDIFICATION

White iron is cast iron which solidifies with little or none of the graphite constituent which is characteristic of gray iron. White cast iron is produced by:

1) rapid freezing (chilled iron).
2) low silicon and/or carbon contents.
3) additions of sulfur or tellurium.
4) by alloying with carbide stabilizing alloys such as chromium and manganese.

Often several of these factors are used in combination. For example, when silicon content is held as low as feasible, an alloy addition of chromium may be desirable to insure that graphite formation is suppressed.

The solidification shrinkage of white iron is about 5½ per cent, and white iron castings require feeding from risers to produce sound castings.

Hypoeutectic White Irons

With a silicon content of around 0.50 per cent, the eutectic carbon content of low phosphorus iron is about 4.10 per cent to 4.15 per cent, so most white irons are hypoeutectic. On cooling to the liquidus, austenite dendrites begin to form at the mold wall and grow progressively inwardly throughout the section. Since the solid austenite dendrites contain less carbon, say around 1.5 per cent C, the remaining liquid is enriched in carbon until the last liquid is of eutectic composition.

When the melt has cooled to the eutectic temperature, eutectic solidification begins. The product of eutectic solidification is ledeburite, mixed crystals of saturated austenite and iron carbide. The final solidified structure then consists of austenite in a dendritic pattern and ledeburite mixed crystals between the dendrites. The lower the carbon equivalent, the greater will be the proportion of primary austenite. With eutectic carbon equivalent, the solidified structure is 100 per cent ledeburite.

Hypereutectic White Irons

With white irons exceeding the eutectic in carbon equivalent, the first constituent to solidify is primary iron carbides. Iron carbide contains about 6.67 per cent carbon, so the remaining liquid is progressively lowered in carbon equivalent until the eutectic temperature is reached. Eutectic solidification produces ledeburite.

GRAY IRON SOLIDIFICATION

Gray iron is cast iron in which graphite is one constituent of the solidified metal. Usually, the graphite is in flake form, although some authorities consider

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nodular or ductile iron to be in the gray iron family. For this discussion, we will use the term gray iron to mean flake graphite gray iron.

The most important practical effect of graphite precipitation during solidification is the resulting expansion which may compensate for the normal solidification shrinkage. It has been stated that 2.80 per cent of graphitic carbon nullifies the solidification shrinkage so that risering to feed shrinkage cavities is not necessary (a cu in. of iron weighs 0.28 lb while a cu in. of graphite weights 0.08 lb).

Mold wall movement is a critical factor in the shrinkage characteristics of gray iron castings. If the expansion due to graphitization is allowed to expand the mold wall by deformation, shrinkage and internal porosity may occur with any iron composition. With rigid molds this is not permitted to occur, and sound castings can be obtained without risers when sufficient graphite is precipitated.

Hypoeutectic Gray Irons

In iron compositions where the carbon equivalent is less than the eutectic, primary austenite in the dendritic form is the first constituent to freeze. Solidification of austenite continues until the remaining liquid is of the eutectic composition. Then, eutectic solidification begins at crystallization centers which grow radially to form eutectic solidification cells. Graphite flakes begin to form when eutectic solidification begins.

Flakes grow in a generally radial pattern from the eutectic crystallization centers outwardly into the remaining eutectic liquid. On completion of solidification, the solidified eutectic cells and all the graphite occupy the spaces between the primary dendrites previously formed. On subsequent cooling, further growth of the original graphite flakes may penetrate into the original dendrites by solid graphitization.

It is generally accepted that the original graphite flakes formed in the eutectic crystallization centers grow with the outer edge of the flakes in contact with eutectic liquid. Graphitization, after solidification, occurs simply by adding on of precipitated carbon to the existing flake pattern.

The size and pattern of the graphite flakes is largely determined by the number and size of the eutectic cells and the degree of undercooling before eutectic solidification begins. With little or no undercooling, the eutectic cells are small and numerous; and the graphite patterns tend to the Type A graphite, uniform flake distribution with random orientation. When considerable undercooling occurs before the eutectic solidification starts, the eutectic cells are large and less numerous; and the final graphite pattern tends to the Type D, interdendritically segregated flakes.

With little or no undercooling, graphite flakes grow slowly during gradual eutectic solidification from numerous cells in relatively large flakes which can finally grow into the austenite dendrites to give a rather uniform distribution.

With considerable undercooling flake formation is rapid in large cells, resulting in smaller flakes segregated between dendrites. Inoculants are widely used to prevent or reduce undercooling and to produce Type A graphite.

Hypereutectic Gray Irons

Solidification of hypereutectic gray iron begins by the precipitation of primary graphite flakes. There is a rather academic question as to whether the initial precipitation is graphite from the liquid, or iron carbide which immediately decomposes to graphite. The net result is the same in that primary graphite appears in the melt prior to eutectic solidification.

When eutectic composition is reached the eutectic solidification proceeds exactly as in hypoeutectic gray irons.

NODULAR OR DUCTILE IRON SOLIDIFICATION

Ductile irons are gray irons in which the graphite phase occurs essentially in the form of spherulites rather than in the usual flake form. Compositionally, ductile iron may be quite similar to normal gray iron with the important exception that the sulfur content, which could combine as FeS and MnS, is essentially nil.

A few hundredths of per cent of a nodulizing agent such as Mg or Ce is usually considered to be an essential part of the composition of ductile iron, although, the effectiveness of these elements may likely be due to their ability to combine with the last traces of sulfur in the melt. Since phosphorus embrittles ductile iron to a greater degree than normal gray iron, this element is usually held to a low content in commercial ductile irons. Carbon and silicon can be in the normal range, but since manganese is not required to combine with sulfur, this element may be quite low, or even absent.

Hypoeutectic Ductile Irons

The general progress of solidification of ductile iron is generally similar to that of normal gray iron of the same carbon equivalent. There are differences, but these are comparatively minor considering the difference in resulting structure and properties.

As in the normal gray iron, solidification begins by the formation of austenite dendrites followed by eutectic solidification. It is probably significant that ductile irons consistently undercool several degrees below other irons of similar composition. Eutectic solidification begins in the order of 10 to 30 F lower.

Figure 1 from Pellini* compares the solidification in 7 in. square sections of gray and ductile hypoeutectic irons. As shown by these diagrams, the greatest difference is in the eutectic solidification, which in the case of ductile iron is considerably more extended and slower. Pellini and others consider that carbides form first at the beginning of eutectic solidification and later decompose to graphite spherulites and austenite. It is generally agreed that graphite spherulites do not grow in contact and liquid metal, but at their inception and during subsequent growth are surrounded by a solid shell of austenite. There is ample

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evidence that this is true, but the reason why is a matter for speculation at the present state of knowledge.

Spherulite Formation

There are several areas of uncertainty and even disagreement concerning the solidification of ductile irons. Most investigators assume that spherulites do not begin to form until the start of the eutectic solidification. There is some evidence, however, that at least the nuclei for spherulites may form in the austenite dendrites prior to the eutectic solidification. The undercooling which occurs before eutectic solidfication starts could contribute to this mechanism.

Figure 2 is a micro of a hypoeutectic iron with low (0.004 per cent) total Mg content. Both spherulites and Type D or eutectiform flake graphite are present. It is obvious that the Type D flake graphite formed in the eutectic or last to freeze metal. But the spherulites present appear consistently in the center of austenite dendrites. It is difficult to reconcile this with nodule genesis in the eutectic only.

Another area of uncertainty is in whether graphite spherulites always form by decomposition of solidified carbides or if graphite may form directly from the melt. The spherulites or nodules in Fig. 2 do not appear to have formed by carbide breakdown since they are centrally positioned in what appears to be primary austenitic dendrites. Evidence for spherulite formation by carbide breakdown is found in the fact that spherulites can be formed by annealing carbidic white iron.

Even this is not positive evidence of spherulite initiation from carbide breakdown. We have examined many samples of chilled magnesium treated iron microscopically. Although these chilled samples appear to be truly white iron, under high magnification (in most cases) tiny graphite spherulites can be detected. On annealing, these incipient spherulites already present simply grow by diffusion of carbon from carbide through austenite.

Pellini and co-workers have shown that the number of spherulites in ductile iron at the beginning of eutectic solidification is the same as after complete solidification, and that only the size of the spherulites increases as solidification progresses. This could mean that tiny graphite spherulites form at or just prior to eutectic solidification in the austenite dendrites, and thence simply grow by diffusion of carbon.

While the overall mechanism of solidification of hypoeutectic ductile irons is generally understood, it is uncertain (at least to the writer) whether or not incipient spherulites may form prior to eutectic solidification. Stated another way, it is uncertain whether or not incipient spherulites may form before eutectic carbides have solidified.

Hypereutectic Ductile Irons

The solidification of hypereutectic ductile iron begins by the precipitation of primary graphite spherulites. Whether or not primary carbides form first and immediately breakdown to spherulites and austenite is rather inconsequential, since the net result, graphite spherulites in the melt prior to eutectic solidification, is the same. It is generally agreed that primary graphite spherulites, in contrast to primary flakes, are sourrounded from inception by a shell of solid austenite and grow out of contact with liquid metal.

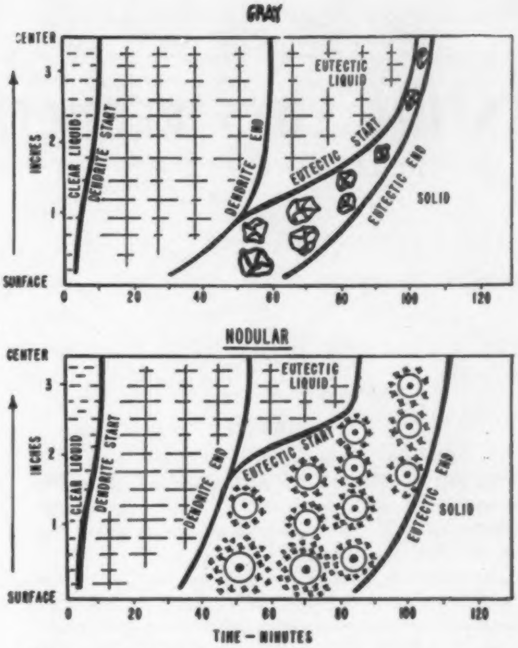

Fig. 1 — Solidification diagrams for hypoeutectic flake (top) and nodular (bottom) irons (Pellini).

Evidence for this is rather clear. Flotation of graphite spherulites in hypereutection ductile irons has been reported many times. This is exaggerated in centrifugal castings, and a concentration of primary spherulites at the inside of true centrifugal castings is obvious when the metal is hypereutectic, but ceases abruptly when carbon content is less than eutectic. Evidence for the austenite shell around the spherulites is found in the fact that while primary spherulites float in the liquid toward the surface, they do not eject completely out of the liquid into the air as is the case in ordinary kish primary flake graphite.

When primary graphite has precipitated in the liquid to the extent that eutectic concentration is reached, eutectic solidification proceeds as in any ductile iron.

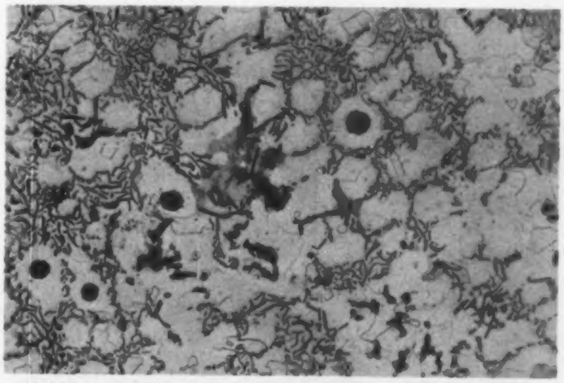

Fig. 2 — Micrograph of hypoeutectic cast iron with 0.004 per cent total magnesium content. Nital etch. 100 ×.

CASTING LOSS REDUCTION PROGRAM

by Harry W. Dietert

ABSTRACT

The reduction of casting losses is a paramount issue in the casting industry. The production of high quality castings demands close inspection which means high rejection should quality control in the foundry ever lose its efficiency.

The efficiency of quality control can best be held at a good working peak when casting losses are correctly classified and their elimination procedure is well understood. A definite plan of action is essential. The purpose of this report is to set forth a programming plan for casting loss reduction. It will not cover the entire field but will cover the field of losses obtained from inefficient working of molding sand which may be used as an example to attack the other losses experienced.

STEPS IN PROGRAM

1 — Programming According to Source

The first step is to program the attack from the source of the loss. It is essential to determine the source of the loss.

The program may be started by recognizing that there are six principal sources of casting losses, namely: design, metal, pattern equipment, molding equipment, core and molding sand. All casting losses may be ascribed to one of the six named sources.

2 — Programming According to Classification

After the source of loss has been determined, a second step must be taken to determine whether the loss may be classified as to whether it was man-made due to the human variable, carelessness in working or whether the loss can be classified as being caused by the source not being capable of performing its task.

Thus, we have man-made losses in each of the six sources. As an example, a scab caused by a gagger too close to pattern. The source is molding sand and it must be classified as man-made. Conversely, an expansion scab due to mold wall fracturing has as its source molding sand also but it must be classified as molding sand-made.

The man-made losses are much more numerous than source-made losses. Take for example the source of molding sand losses. In the tables there are listed 101 molding sand man-made losses and 29 molding sand-made losses. This illustrates the importance of delegating a well trained staff on the control of losses that are man-made by the human variable.

3 — Programming the Cause

At this stage of programming the reduction of loss we have determined the source and have classified it as to whether the loss comes directly from failure of our source or whether it is man-made. The third step is to reason the cause. In man-made classification, the cause may be failure to follow instructions or not instructed correctly.

In the case of source-made classification, for example, molding sand-made losses, the cause of expansion losses such as a scab, is the rate of expansion of sand greater than the rate of hot deformation.

4 — Programming According to Correction

After the cause is determined a fourth step is taken – correction. The correction of the loss is an important step in the program. Some corrective step must be taken and that step must be commanded. Have a clear and precise correction formulated and then execute it so as to remove the cause by certain changes.

5 — Programming According to Changes

Step 4 left us with a precise formulated correction, and now as to its execution a certain change must be made. Thus, step 5 is to make a definite change. Whether the loss is man-made or source-made, a change must be made to eliminate a loss. The change made must be corrective and precise.

APPLICATION

Illustrating the application of the suggested loss reduction program may be best accomplished by first taking as an example, the source-molding sand. All the losses of molding sand are divided into the two classifications, molding sand-made and molding sand man-made. The molding sand-made losses are tabulated in Tables 1 to 6, inclusive. The molding sand man-made losses are tabulated in Tables 7 to 12, inclusive.

Molding Sand-Made Losses

The dirt inclusion losses which have their source as molding sand are caused by a failure of the

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molding sand. Table 1 can be used to illustrate the application of the loss reduction program.

Table 1 shows three types of dirt inclusion losses – erosion, sand inclusion and sand holes. The cause is shown as metal erosion of the mold surface. If the sand inclusion was present due to any other cause, it would be a molding sand man-made loss and should be included in losses tabulated in man-made losses Tables 7 to 12, inclusive.

Proceeding with the molding sand-made loss in Table 1, with cause prescribed, the next step shown is correction. The corrections shown are–increase green strength, air-set strength, dry strength and hot

TABLE 1 — MOLDING SAND-MADE DIRT INCLUSION LOSSES

Type: Erosion — sand inclusion — sand holes.

Cause: Metal erosion of mold surface.

Correction: Increase green, air-set and dry strength and hot toughness.

Sand Change:

1. Temper sand to 0.016 in. to 0.018 in. green ultimate deformation except steel, 0.022 in. to 0.025 in.
2. Run 14 to 18 psi green compressive strength.
3. Add dextrine if air-set is below 20 psi.
4. Run 60 to 125 psi dry strength. Add cereal if necessary.
5. Increase hot strength with Western bentonite or clay additions.

TABLE 2 — MOLDING SAND-MADE BLOW LOSSES

Type: Surface blow — gas hole in metal.

Cause: Gas pressure at metal-mold interface greater than molten metal pressure.

Correction: Cause gas pressure of sand to be less than molten metal pressure.

Sand Change:

1. Increase permeability of sand.
2. Run green compressive strength at 14 to 18 psi and temper sand to 0.016 to 0.018 in. ultimate green deformation to avoid excess mechanical moisture.
3. Increase molten metal pressure head.
4. Reduce gas producing ingredients.

TABLE 3 — MOLDING SAND-MADE MOLD WALL FRACTURE LOSSES

Type: Rat tail — buckle — expansion scab — fracture dirt.

Cause: Expansion greater than hot deformation.

Correction: Decrease 1 lb loaded expansion above 0.007 in. for iron and non-ferrous; decrease restraining load below 50 psi for steel.

Sand Change:

1. Limit fines under 8 to 12 per cent.
2. Add 1 to 2 per cent Flour.
3. Add 1 to 2 per cent corn cereal binder or carbonaceous material.
4. Use special sand, i.e., carbon-chamott-sillimanite or zircon.

TABLE 4 — MOLDING SAND-MADE MOLD WALL MOVEMENT LOSSES

Type: Casting over-weight — low casting density — poor dimensional tolerances — some shrinks — swells.

Cause: Sand will not sustain metal weight.

Correction: Decrease creep deformation under 0.003 in. at 5 psi — 2 min.

Sand Change:

1. Run green compressive strength at 14 to 18 psi.
2. Temper to 0.016 to 0.018 in. ultimate green deformation.
3. Run ample fines up near mold wall fracture percentage.
4. Add 1 to 2 per cent cellulose material.
5. Add 4 to 6 per cent sea coal for iron.
6. Add flowability increasing ingredient.

TABLE 5 — MOLDING SAND-MADE PENETRATION LOSSES

Type: Metal penetration — penetration burn-on.

Cause:

1. Excess void size.
2. Excess oxidizing atmosphere.
3. Excess metal pressure.

Correction:

1. Reduce size of voids on mold wall.
2. Displace oxidizing gases at metal-mold interface.
3. Decrease molten metal pressure head.

Sand Change:

1. Decrease grain size — lower permeability.
2. Increase flowability by holding ultimate green deformation to 0.016 in. to 0.018 in. except steel 0.022 in. to 0.025 in. and running green compressive strength, 14 to 18 psi.
3. Use reducing additives.
4. Use insulated sprues and headers as means of reducing metal pressure head.
5. Reduction of metal pressure against sand during metal expansion cycle.

TABLE 6 — MOLDING SAND-MADE ROUGH CASTING FINISH LOSS

Type: Roughness — coarse finish.

Cause: Coarse mold surface.

Correction:

1. Increase fineness.
2. Use protective coating.
3. Increase green strength to attain higher hardness.

Sand Change:

1. Use finer sand — watch distribution.
2. Add facing material to sand.
3. Apply mold coating.
4. Increase green strength, 14 to 18 psi.
5. Temper sand to 0.016 in. to 0.018 in. ultimate green deformation.

toughness. Any one of the strength factors shown may be deficient.

Thus, the task is to determine which one of the strength factors is at fault. This determination can best be made after all strengh test data are studied. Sand erosion in the hot region is not a factor of hot strength alone but also of hot deformation. Thus, the two factors must be considered together as hot toughness.

The sand changes suggested in Table 1 for correction of dirt inclusion of molding sand-made losses are five in number. Make the sand changes as shown to correct the deficient strength factor as found by sand tests. For example, sand change, the air-set strength was found to be below 20 psi. The change No. 3 suggests the use of dextrine to increase the air-set strength.

A study of the other Tables (2 to 6), inclusive, will show steps suggested for other molding sand-made losses. Their application for the reduction of losses may be used as a guide, remembering that they are in a simplified form and in their application, much thought must be given to inter-linking effects on other sand working properties.

TABLE 7 — MOLDING SAND MAN-MADE DIRT INCLUSIONS LOSSES

Type: Erosion — sand inclusions — sand hole.

Causes:

1. Poor gating equipment, no draft, fin producing areas and joints.
2. Failure to keep sprue filled with metal.
3. No choke on trap in gating system.
4. Dirt left in gating system.
5. Dirt left in mold.
6. Crush at parting.
7. Crush at print.
8. Low mold hardness due to soft ramming.
9. Dirt kicked in mold.
10. Dirt from overhead beams.
11. Dirt blown in mold.
12. Excess dry parting.
13. Excess paste or putty at joints.
14. Dry sand.
15. Poorly mixed sand.
16. Hot sand dried out.
17. Poorly cut gates.
18. Ingate too thick.
19. Sprue too close to flask.
20. Failure to use strainer.
21. Cuff of shirt sleeve scuffing mold.
22. Foreign material in sand.
23. Using dried out sand.
24. Dry sand from bin corners.
25. Excess dry mold dusting material.
26. Crush due to use of excess seal at prints.
27. Ram-off dirt.
28. Push-up drag from bottom boards.
29. Warped flask causing crush.
30. Flask not down on pattern plate.
31. Bridging in sand bins.
32. Accumulation of dried out sand in hoppers.
33. Caking of sand on mixer walls.
34. Using soured sand.

Correction: Control human variable.

Man Changes:

1. Issue correct instructions.
2. Have instructions followed.

TABLE 8 — MOLDING SAND MAN-MADE BLOW LOSSES

Type: Blow on surface — blow in metal.

Causes:

1. Excess swabbing.
2. Wet sand from sprinkling.
3. Wet rusty chill.
4. Wet gagger.
5. Excess water on flask.
6. Excess liquid parting.
7. Too hard tooling.
8. Wet Putty.
9. Insufficient venting where required.
10. Bottom board not vented where required.
11. Sand bed too tight.
12. Excess facing material.
13. Insufficient drying of skin dried mold.
14. Wet mold coating.
15. Facing material mixed nonuniformly.

Correction: Control human variable.

Man Changes:

1. Issue correct instructions.
2. Have instructions followed.

TABLE 9 — MOLDING SAND MAN-MADE MOLD WALL FRACTURE LOSSES

Type: Buckle — scab — fracture losses.

Causes:

1. Excess tooling.
2. Gagger too close to pattern.
3. Bar too close to pattern.
4. Butt rammed too close to pattern.
5. Large flat area not relieved by change in plane.
6. Non-uniform mold hardness.
7. Excess moisture in low strength sands coupled with hard ramming.
8. Failure to add cellulose or combustible material in sand mixer.
9. Not riddling sand if lumpy.
10. Insufficient nails where nailing is practiced.
11. Insufficient venting where such is practiced.
12. Added wrong ingredients to the sand.

Correction: Control human variable.

Man Changes:

1. Issue correct instructions.
2. Have instructions followed.

Molding Sand Man-Made Losses

The losses experienced from the molding sand source, but classified or charged to man-made, are large in number. The utmost care can be practiced in the selection of equipment or materials and all to no saving should the human variable be in control. The control must be in both the equipment-material and in the human variable.

Table 7 lists 34 causes of casting loss due to dirt inclusion for the molding sand man-made losses. The type of loss is the same, namely, erosion, sand inclusions and sand hole, as for the dirt inclusion losses shown in Table 1 for the molding sand-made losses. They are the same source since the inclusion is molding sand and the type is the same loss. However, they are man-made which distinction must be made. It is of utmost importance in a loss reduction program to make this distinction.

The causes of man-made losses are sometimes difficult to pin down, for example, dirt inclusion loss which is composed of molding sand. If the sand is not eroded from the mold surface then it is man-made. Study the 34 causes (Table 7) which are chargeable to man. Determine the right cause by a process of elimination if no better method presents itself.

The next step is to make the correction by controlling the human variable. This incurs a man change, whereby the correct instructions are first determined and then see that the instructions are followed. This is easier said than done, but yet possible.

TABLE 10 — MOLDING SAND MAN-MADE MOLD WALL MOVEMENT LOSSES

Type: Excess casting weight — low casting density — poor dimensional tolerances — swells — some shrinks.

Causes:

1. Sand segregation.
2. Insufficient ramming energy available.
3. Insufficient air pressure.
4. Jolt machine whip.
5. Failure to move sand slinger head fast enough.
6. Failure to tuck where required.
7. Failure to use contoured squeeze board where required.
8. Non-uniform filling of flask with sand over pattern.
9. Insufficient jolting.
10. Failure to hold squeezing time constant.
11. Squeeze board catches on flask.
12. Variable quantity of sand in flask.
13. Poor selection of up-set on flask.
14. Flask too close to pattern.

Correction: Control human variable.

Man Changes:

1. Issue correct instructions.
2. Have instructions followed.

TABLE 11 — MOLDING SAND MAN-MADE PENETRATION LOSSES

Type: Metal penetration — penetration burn-on.

Causes:

1. Insufficient ramming.
2. Excess toughness of sand.
3. Excess cope height.
4. Coarse sand from sand segregation.
5. Failure to check fineness of incoming sand.
6. Insufficient mold coating.
7. Insufficient drying of mold coating.
8. Excess squeeze pressure on mold surface due to metal expanding on setting.
9. Using wrong sand mix.

Correction: Control human variable.

Man Changes:

1. Issue correct instructions.
2. Have instructions followed.

CONCLUSION

Improving the quality of castings requires a well directed plan. A systematic and orderly program instituted along the line of the program tables given in this paper will be found helpful. The program must be applied and simple; as outlined it has been simplified to the greatest degree. Thus, in their use, additional thought should be given to guide their application to the problem at hand.

TABLE 12 — MOLDING SAND MAN-MADE ROUGH CASTING SURFACE LOSS

Type: Roughness — coarse finish.

Causes:

1. Failure to use facing material.
2. Insufficient facing material.
3. Coarse sand from segregation.
4. Wet sand sticking to pattern.
5. Insufficient mold hardness.
6. Failure to use parting.
7. Cold pattern causing sticking.
8. Failure to riddle sand on pattern.
9. Failure to use aerator in sand system.
10. Hot sand sticking on pattern.
11. Lumpy sand.
12. Pattern too close to flask.
13. Damaging pattern with rammer.
14. Using rough pattern.
15. Poor fitting fillets on pattern.
16. Poor draft on pattern.
17. Using dried out sand.

Correction: Control human variable.

Man Changes:

1. Issue correct instructions.
2. Have instructions followed.

ALUMINUM CASTING ALLOYS PROPERTIES IMPROVEMENT BY GRAIN REFINING

by K. Schneider

ABSTRACT

The properties of aluminum casting alloys may not only be changed by altering their composition or, in the case of heat treatable alloys, by a thermal treatment, but also by influencing their crystalline structure. This may be achieved either by controlling the cooling conditions during solidification or by making additions influencing the formation of the structure. Fine grained castings in general show more favorable technological properties than those having a coarse grained structure.

The theoretical conditions under which aluminum alloys may be grain refined by adding a nucleant are discussed.

It is reported on investigations regarding the grain refinement of hypereutectic aluminum-silicon alloys by means of phosphorus bearing nucleants as well as on the development of a grain refining agent on this basis, and the conditions for its most efficient application are given. Reference is made to the effect of small quantities of sodium and calcium in hypereutectic aluminum-silicon alloys on the grain refinement of these alloys. Also pointed out is the importance of grain refinement for the use of hypereutectic aluminum-silicon alloys in the production of pistons.

A method is described for grain refining aluminum-magnesium alloys by treating them with chlorides of carbon, above all carbon tetrachloride which is introduced into the metal melt by means of an inert carrier gas. The tests were carried out on alloys containing 2 to 8.5 per cent magnesium. The improvement of mechanical properties achieved by the grain refining treatment is indicated.

INTRODUCTION

Pure aluminum has comparatively low strength properties and relatively poor castability. For this reason it is only used to a limited extent in the production of castings for special purposes where particular properties, such as especially good electrical conductivity or maximum resistance to corrosion, are required. The properties of pure aluminum can, however, be altered substantially by adding one or several metals as alloying constituents.

Therefore, aluminum alloys are used in the foundry which have properties superior to those of pure aluminum in castability, free-cutting characteristics, strength and hardness, thermal expansion, resistance to chemical attack, thermal conductivity or strength at elevated temperatures.

The properties of aluminum alloys may, however, only be influenced by the addition of various alloying elements, but also by other factors. Thus, ultimate tensile stress and proof stress of heat treatable alloys may be improved considerably by a thermal treatment. Technological properties are to a certain degree also dependent on the crystalline structure of the alloy. Tests have shown that, e.g., tensile strength and elongation are improved by 8 to 10 per cent in the case of alloys solidified in fine grains compared to coarse grained castings.

While with the multitude of known casting alloys the possibility of improving their properties by altering the levels of alloying elements is almost exhausted, there is still a way to achieve this aim by influencing the crystalline structure during its formation when the melt solidifies.

GRAIN SIZE CONTROL OF ALUMINUM ALLOYS

Slow cooling of the melt initiates crystallization at the mold wall, the nuclei produced preferably growing into the melt in the form of columnar crystals. Rapid cooling, on the other hand, yields a high rate of crystalline growth; as a consequence, fine grains are formed while orientated crystallization is prevented. Use of this fact is frequently made in practice. It is extremely difficult, however, and on intricate molds next to impossible to obtain uniform cooling conditions over the entire cross-section of a casting. An attempt has therefore been made to find another way to produce fine grains.

Considering the possible approaches to this problem, the mechanism of freezing in a metal melt should be briefly recalled. Pure aluminum, as well as eutectic alloys, solidifies at an approximately fixed temperature forming uniform crystals. All other alloys have a freezing range in which not only pure metal crystals but also a variety of solid solutions are precipitated. If, therefore, the crystalline structure is to be influenced during solidification, the methods used for pure aluminum and eutectic alloys must be different from those applicable to the remaining types of alloys.

It is a well-known fact that slow freezing produces large crystals, the crystals being the larger the purer the melt. If, however, nuclei are introduced into un-

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dercooled melts to initiate sudden freezing, a fine grained structure is produced, the number of crystals forming being dependent on the number of nuclei.

This phenomenon is made use of in the so-called modification of eutectic aluminum-silicon alloys. In the as-cast condition they have a coarse structure in which aluminum-silicon crystals are embedded. Adding sodium to the melt effects undercooling; the result is a solidification in a fine grained form of the aluminum-silicon eutectic with embedded primary aluminum-silicon crystals.

Solid Solution Crystals

In other than eutectic alloys there are, apart from crystals of the pure metal, numerous solid solution crystals of various shapes, which, e.g., may have face-centered cubic or hexagonal crystal structure. If these crystals are to be influenced during solidification of the melt by the addition of agents, the nuclei produced must have a higher melting point than the metal, i.e., they must not be dissolved unless they precipitate again prior to solidification of the metal.

Furthermore, a certain crystallographic similarity between the nuclei and the solidifying metal is necessary; the two crystal structures should have lattice planes exhibiting the same arrangement of atoms and approximately equal interatomic spacing.[1] Thus, for instance, crystals with a hexagonal space lattice can act as precipitation nuclei for aluminum which forms crystals of the face-centered cubic system, if the difference between the smallest interatomic spacings of the two crystals is, in one dimension, less than 15 per cent.[2]

Therefore, depending upon the alloy to be grain refined, different agents have to be used. By applying several nucleants at the same time, various types of crystals in an alloy can be grain refined.

Recently, some success has been achieved in developing grain refining methods for hypereutectic aluminum-silicon and aluminum-magnesium alloys; these tests will be extended to include other aluminum alloys.

GRAIN REFINEMENT OF HYPEREUTECTIC ALUMINUM-SILICON ALLOYS

Hypereutectic aluminum-silicon alloys have been used in Europe in recent years to an ever increasing extent for the production of pistons in internal combustion engines. These alloys in addition to 17 to 25 per cent silicon may also contain copper, nickel, magnesium, chromium, cobalt and other metals; they offer the advantage of having especially good anti-friction properties and low thermal expansion.

When these alloys are cast, the primary silicon tends to form in large crystals, as is illustrated in Fig. 1 showing the structure of an aluminum-silicon alloy with 23 per cent silicon. This characteristic has an unfavorable effect on castability, and also on the technological properties and machinability.

In order to obtain fine, uniformly distributed silicon crystals upon solidification, a grain refining agent must be added to the molten metal which, as was mentioned above, should have the same crystal structure and approximately the same lattice spacing as silicon. Aluminum phosphide fulfils this condition; its struc-

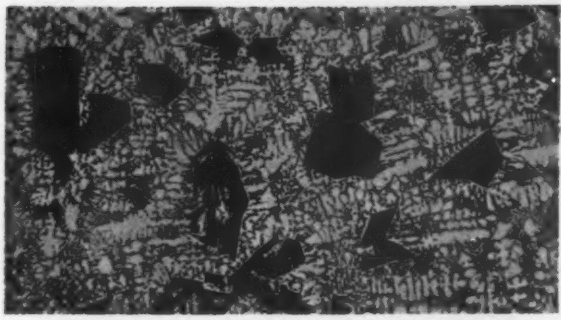

Fig. 1 — Structure of aluminum-silicon casting alloy containing 23 per cent silicon. 100 ×.

ture is also cubic and its lattice spacing of a = 5.45 Angstrom is approximately the same as that of silicon where a = 5.42 Angstrom.

Therefore, phosphorus has for a long time been used for refining hypereutectic aluminum-silicon alloys. When added to the melt the phosphorus reacts with aluminum forming finely distributed aluminum phosphide. In practice, the addition of phosphorus is made in the form of phosphor copper. This produces a certain increase of the copper content in the alloy.

In order to avoid this, phosphorus may be introduced into the melt in the form of phosphorus pentachloride. This salt, however, is highly hygroscopic and easily decomposed. It sublimes at a temperature as low as 212 F (100 C), and, therefore, must be handled carefully. Besides, unpleasant fumes are evolved when it is applied.

Sodium Phosphide-Aluminum Powder Mixture

For this reason, it has been suggested to use a mixture of sodium phosphide and aluminum powder for refining hypereutectic aluminum-silicon alloys.[3] At the temperature of the molten metal, a chemical reaction takes place by which aluminum phosphide is formed; the aluminum phosphide nuclei are produced in the melt in an especially effective form and are finely distributed. Experience, however, has shown that it is not always possible to obtain good results by this method.

This is attributed to the use of sodium phosphide as the carrier substance for phosphorus. The affinity of sodium for phosphorus at the temperature of the metal melt is greater than that of phosphorus for aluminum. Aluminum phosphide formed at the high temperature of the chemical reaction is partly retransformed into sodium phosphide at the lower temperature of the melt and part of the phosphorus is lost for nucleation.

Furthermore, a grain refining agent containing only phosphorus can exclusively influence the primary silicon crystals, but not the matrix.

For obtaining optimum grain refining effects in hypereutectic aluminum-silicon alloys, a sodium-free agent should be used which, apart from phosphorus, contains also a nucleant for the matrix. Since it is known that small amounts of titanium improve the formation of nuclei effecting a refinement of the α

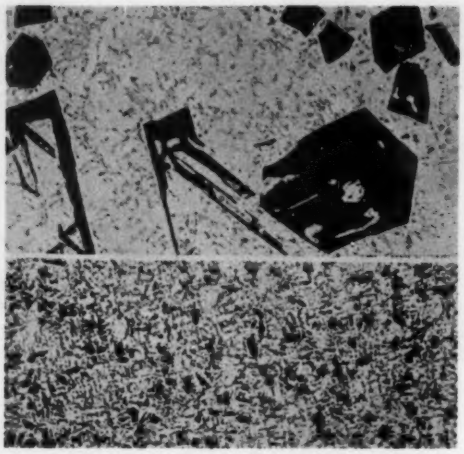

Fig. 2 — Structure of aluminum-silicon casting alloy containing 17 per cent silicon. *Top* — untreated; *bottom* — refined. 100 ×.

solid solution, it has been proposed[4] to use a grain refining agent which contains red phosphorus as carrier substance for phosphorus and potassium-titanium-fluoride as carrier for titanium.

This mixture is ground together with potassium-chloride serving as carrier salt for the red phosphorus, and as a purifying agent for the melt at the same time.

Tests were made with hypereutectic aluminum-silicon alloys containing 17 and 23 per cent silicon. Their composition is given in Table 1.

By means of a plunger 0.8 to 1 per cent of the grain refining medium is introduced into the melt heated to 1435 F (780 C), and after turbulence has ceased the alloy is cast at 1380 to 1420 F (750 to 770 C). The result obtained is clearly exhibited in Fig. 2, which shows on the top the structure of an untreated and on the bottom that of a refined aluminum-17 per cent silicon alloy. Figure 3 illustrates the same effect for an aluminum-23 per cent silicon alloy.

The particle size of the grain refining mixture is

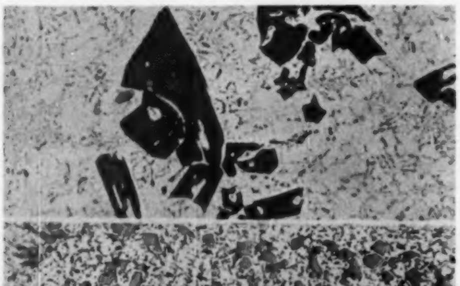

Fig. 3 — Structure of aluminum-silicon casting alloy containing 23 per cent silicon. *Top* — untreated; *bottom* — refined. 100 ×.

TABLE 1 — CHEMICAL COMPOSITION OF HYPEREUTECTIC ALUMINUM-SILICON ALLOYS

	Casting Alloy Composition, %	
Element	AlSi 17	AlSi 23
Cu	0.8-1.2	0.8-1.2
Mg	0.7-1.2	0.7-1.2
Mn	0.4-0.6	<0.2
Si	16.4-17.5	22-25
Fe	<0.8	<0.8
Ti	<0.2	<0.2
Zn	<0.2	<0.2
Ni	3.2-3.6	0.8-1.0
Cr	0.4-0.6	0.4-0.6
Al	remainder	remainder

of decisive importance for its effectiveness in nucleation. Optimum results are obtained, when the length of the salt crystals is between 20 to 60 microns. Coarser mixtures clearly produce less favorable grain refining effects. This is illustrated in Fig. 4. The structure on the top is that of an untreated aluminum-silicon alloy with 17 per cent silicon. The alloy shown in the middle was refined with a mixture of salt crystals having a partical size of 140 to 600 microns, while the salt crystals in the grain refining mixture used for treating the alloy on the bottom were of 20 to 60 microns size.

It proved to be of advantage to flux the melt with chlorine after the grain refining treatment prior to casting. The aluminum phosphide nuclei are activated favoring the formation of many small crystals. About 200 liters of chlorine gas are bubbled through a 150 kg melt at a temperature of 1380 to 1420 F (750 to 770 C). The effect of such a treatment is illustrated in Fig. 5, which shows the structure of a refined aluminum-23 per cent silicon alloy prior to the chlorine gas treatment on the top and after it on the bottom.

If the refined molten alloy is held at the casting temperature of 1380 to 1420 F (750 to 770 C) for a prolonged period, the grain refining effect is partly lost. By repeating the chlorine gas treatment, however, the fine distribution of the primary silicon crystals can be re-established so that a new grain refining treatment is not necessary.

Sodium Content Effect

As already mentioned, the sodium content has a deleterious effect on the grain size when hypereutectic aluminum-silicon alloys are treated with a phosphorus-bearing grain refining agent. This is confirmed by unpublished experiments carried out by J. Sulzer and V. J. Zabek; the outcome of their work is compiled in Table 2. With 0.001 per cent sodium in the original alloy the average grain size of the primary silicon was 25 microns in aluminum-20 per cent silicon alloys which were treated with a mixture of red phosphorus, potassium chloride and potassium-titanium-fluoride, while with a sodium content of 0.015 per cent an average grain size of 45 microns was obtained. Calcium has a similar effect.

For this reason, if hypereutectic aluminum-silicon alloys contain sodium or calcium, which generally is not the case, these elements would have to be re-

moved by chlorine fluxing prior to the grain refining treatment.

The extent to which hypereutectic aluminum-silicon alloys are used at the present time for pistons in internal combustion engines in Europe has only become possible due to the development of grain refining methods which can easily be applied and always yield good reproducible results. The fine grained structure of hypereutectic aluminum-silicon piston alloys is of special importance for their machinability.

Excessive Tool Wear

When large primary silicon crystals are unevenly distributed the hard silicon causes excessive wear of the tools. The service life of the tools is thus reduced, and uneven heating of the workpiece may occur. With the mean linear thermal expansion of the alloy being 17.5×10^{-6} mm/mm C in additional rise in temperature of 10 C on a piston having a 100 mm diameter means a variation in diameter of 0.0175 mm. This, however, is more than the permissible limit in piston machining.

On machining fine grained alloys, on the other hand, differences in temperature occur to a lesser degree; the chips are more uniform and the service life of the tools is improved.

The fine grain size of hypereutectic aluminum-silicon alloys is of decisive importance for the surface quality of the machined pistons. In the case of a coarse distribution of the primary silicon crystals they tend to be torn out of their environment so that a rough surface results, while with a fine homogeneous distribution of the crystals a considerably smoother surface is obtained.

The effect of grain refinement on surface quality is demonstrated by measurements taken with the Leitz roughness gage, which are shown in Table 3. The surface roughness is also of importance regarding running properties of pistons, gas blow-by and oil consumption.

The technological properties of the hypereutectic aluminum-silicon alloys are also considerably improved by the grain refining treatment. At 70 F (20 C) and after heating for 1 hr at 570 F (300 C), alloys containing 17 to 23 per cent silicon exhibit an increase in tensile strength of 10 to 15 per cent and of 25 per cent in elongation. This is of great importance for the use of these alloys in the production of pistons.

Other possible applications of these alloys are under study. Quite recently, a number of tests have

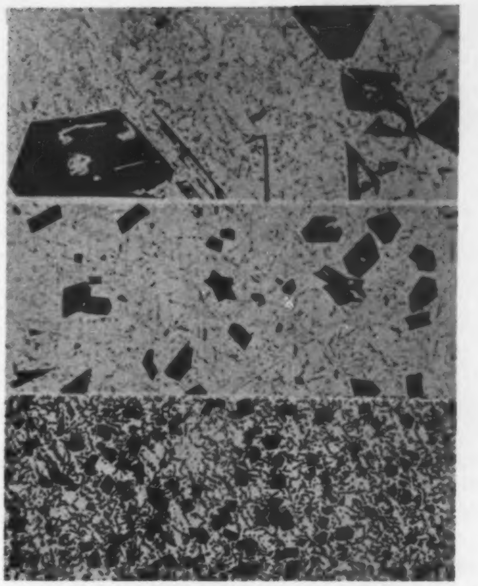

Fig. 4 — Particle size of grain refining agent effect on the structure of an aluminum-silicon casting alloy with 17 per cent silicon. *Top* — untreated; *center* — refined, edge length of grain refining agent being 140 to 600 microns; *bottom* — refined, edge length of grain refining agent being 20 to 60 microns. 100 ×.

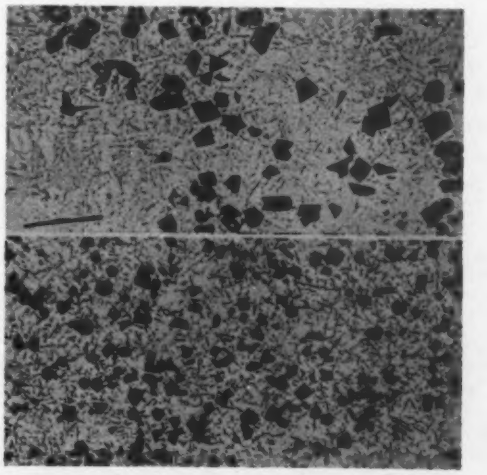

Fig. 5 — Structure of aluminum-silicon casting alloy containing 23 per cent silicon, treated with grain refining agent. *Top* without and *bottom* with subsequent chlorine gas treatment. 100 ×.

TABLE 2 — SODIUM AND CALCIUM EFFECT IN AN ALUMINUM-20 PER CENT SILICON ALLOY (On the Refinement of the Primary Silicon with a Mixture of Red Phosphorus, Potassium-Chloride and Potassium-Titanium-Fluoride)

Na Content before Nucleation, %	Na Content after Nucleation, %	Ca Content before Nucleation, %	Ca Content after Nucleation, %	Avg. Dimension of Primary Silicon, μ
≤0.001	≤0.001	≤0.001	≤0.001	25
0.007	0.004	≤0.001	≤0.001	35
0.008	0.003	≤0.001	≤0.001	32
0.015	0.008	≤0.001	≤0.001	45
≤0.001	≤0.001	0.004	0.002	25
≤0.001	≤0.001	0.019	0.011	30
0.017	0.006	0.017	0.005	35

TABLE 3 — SURFACE ROUGHNESS OF MACHINED PISTON ALLOYS IN MICRONS

Casting Alloy	Grain Distribution	Rough Turned	Fine Turned	Turned with Diamond-Tipped Tool
AlSi 17	untreated	5	3	2.5
	refined	3	2	1.2
AlSi 23	untreated	6	4	4.5
	refined	3.5	2.5	1.5

been carried out in Europe using this type of alloy for making cylinders and cylinder blocks. It was hoped that, in view of the good anti-friction properties of these alloys, the pistons could run directly in the aluminum cylinders. The outcome, however, fell somewhat short of expectations. It seems preferable to make cylinders and cylinder heads of other aluminum alloys and to insert cast iron liners.

GRAIN REFINEMENT OF ALUMINUM-MAGNESIUM ALLOYS

Aluminum diboride (AlB_2), titanium carbide (TiC) and titanium diboride (TiB_2) are reported to be especially effective nucleants for aluminum alloys.[5] In Table 4 the characteristics of these nucleants are shown.[6]

Magnesium bearing aluminum casting alloys generally contain sufficient quantities of titanium and boron to effect grain refinement. It is, however, important that titanium carbide and/or titanium diboride are formed so that they are surface active and that the nuclei created are kept finely dispersed and are prevented from segregating.

In view of the experience gained in refining hypereutectic aluminum-silicon alloys, it seemed advisable to effect nucleation also in aluminum-magnesium alloys by means of a chemical reaction in the molten metal. When gases containing carbon are passed through the aluminum they are decomposed, and the extremely finely distributed atomic carbon reacts with the titanium present in the melt forming titanium carbide; the formation of titanium diboride also seems to be favored by the reactions taking place in the melt.

The use of hydrogen-containing gases, such as methane, did not prove to be successful, as the hydrogen released in the reaction between methane and aluminum is rapidly absorbed by the melt and this results in porous castings. Compounds containing chlorine and carbon, among them especially carbon tetrachloride, on the other hand, are suitable for grain refining aluminum-magnesium alloys. Carbon tetrachloride is not combustible and does not form an explosive mixture with air. Its boiling point is 172.4 F (78 C).

Carbon tetrachloride can thus easily be introduced into the melt in the gaseous phase with the aid of a preheated carrier gas. Nitrogen proved to be successful as carrier gas. Chlorine or other inert gases may also be used for this purpose. When chlorine is employed as carrier gas it must be borne in mind, however, that magnesium in aluminum alloys reacts with the chlorine forming magnesium chloride which is partly removed from the melt, so that the loss has to be made up by the addition of metallic magnesium in order to maintain the composition of the alloy.

TABLE 4 — CRYSTALLOGRAPHIC CHARACTERISTICS OF NUCLEI

Phase	Space Lattice	Type	Lattice Parameter, Angstrom	Smallest Interatomic Spacing, Angstrom	Deviation from Aluminum, %	Melting Point, F (C)
Al	face-centered cubic	A 1	a=4.04	2.82		1220 (660)
TiC	face-centered cubic	B 1	a=4.315	3.04	6.65	≈5800 (≈3200)
TiB_2	densest hexagonal packing	C 32	a=3.026 c=3.213	3.026	5.8	≈5250 (≈2900)
AlB_2	densest hexagonal packing	C 32	a=3.0 c=3.25	3.0	4.9	≈4900 (≈2700)

Aluminum-Magnesium Alloy Tests

Tests were carried out on an aluminum-magnesium alloy containing 4.5 to 5.5 per cent magnesium, 0.1 to 0.6 per cent manganese, 0.6 to 1.5 per cent silicon, maximum of 0.6 per cent iron, 0.6 per cent copper, 0.2 per cent zinc, 0.2 per cent titanium and 0.001 per cent beryllium as well as approximately 0.0005 per cent boron, the remainder being aluminum. Of this alloy 100 kg were melted, and at 1360 F (740 C) 100 liters of nitrogen gas at 175 F (80 C) enriched with carbon tetrachloride were passed through the metal.

Thus, 50 cc of carbon tetrachloride were introduced into the melt; this amount corresponds to 4 g of carbon which is sufficient to effect satisfactory refinement. Simultaneously 15 liters of chlorine gas were formed in the melt which, as a consequence of its fine distribution, affects an especially good degassing and purification of the melt. In order to remove residual gases from the melt, the introduction of nitrogen containing carbon tetrachloride is followed by a short chlorine gas treatment.

The grain refining effect of the method described is shown in Fig. 6. The difference in the fractured structure of an untreated aluminum-magnesium alloy and that of a refined alloy is clearly revealed. Figure 7, showing the microstructure of the same samples, also illustrates the difference in grain size and distribution.

Similar results as for the aluminum-magnesium alloys containing 4.5 to 5.5 per cent magnesium were obtained on aluminum-magnesium alloys with 2 to 8.5 per cent magnesium. Only with higher magnesium contents was the grain refining action of the carbon tetrachloride treatment no longer fully effective.

In the case of aluminum-magnesium alloys the fine grained structure has also a favorable effect on the technological properties, especially on tensile strength at elevated temperatures. As can be seen from Table 5, a fine grained alloy shows a more slight decline in tensile strength and a more slight increase in elongation with rising temperatures over the range from 70 to 570 F (20 to 300 C) than an unrefined alloy.

The notched bar impact strength of the alloy treated with carbon tetrachloride at 570 F (300 C) is 22.4 ft-lb/sq in. (48 cm kg/cm²), and exceeds that of the untreated alloy by 8 per cent. The values of creep strength at room temperature are likewise higher, the increase amounting to 12 to 15 per cent.

As aluminum-magnesium alloys are preferably used for making cylinder heads for air-cooled internal combustion engines, the increase in tensile strength at elevated temperatures obtained by grain refinement

TABLE 5 — MECHANICAL PROPERTIES OF ALUMINUM-MAGNESIUM ALLOYS CONTAINING 4.5 TO 5.5 PER CENT MAGNESIUM

	Test Temp., F (C)		
	70 (20)	480 (250)	570 (300)
0.2% Proof Stress			
ksi	17.2		
kg/mm²	12.1		
Ultimate Tensile Strength			
Before nucleation			
ksi	24.2	19.9	15.6
kg/mm²	17.0	14.0	11.0
After nucleation			
ksi	28.2	24.2	19.2
kg/mm²	19.8	17.0	13.5
Increase, %	16.5	22	23
Elongation on 5.65 $\sqrt{A}$, %			
Before nucleation	2.2	5.5	10.0
After nucleation	2.7	8.3	12.0
Increase, %	68	50	20
Brinell hardness (5/250/30)			
ksi	100-114		
kg/mm²	70-80		

is of special importance. In fact, for engines subjected to high thermal stresses the use of aluminum-magnesium alloys for cylinder heads became only possible when the tensile strength at high temperatures was improved by the grain refining treatment.

CONCLUSIONS

Summing up the results of the tests carried out, it can be said that the most advantageous method for grain refining hypereutectic aluminum-silicon alloys is a treatment of the melt with a mixture of red phosphorus, potassium-chloride and potassium-titanium-fluoride. The edge length of the salt crystals in the refining medium should be between 20 to 60 microns. The salt treatment is to be followed by chlorine fluxing.

If the melt treated with the grain refining agent is held prior to casting for a prolonged period, part of the grain refining effect is lost. However, it can be regained by passing chlorine gas through the melt. Another treatment with the salt mixture is not necessary.

Compared to alloys having coarse primary silicon crystals, hypereutectic aluminum-silicon alloys treated with the grain refining agent have substantially improved machinability, 10 to 15 per cent better tensile strength and 25 per cent higher elongation.

To effect the formation of fine grained crystals in aluminum-magnesium alloys containing 2 to 8.5 per cent magnesium, they are treated with carbon tetrachloride which is introduced into the melt by means of nitrogen as carrier gas. Small amounts of titanium (0.2 per cent maximum) and boron (about 0.0005 per cent) must, however, be present in the aluminum-magnesium alloys.

Compared to the coarse grained aluminum-magnesium alloys, the refined alloys have improved technological properties. The grain refining treatment has a favorable effect on tensile strength at elevated temperatures. In the temperature range between 70 and 570 F (20 and 300 C) tensile strength and elongation are more favorable in the case of fine grained alloys than in the presence of coarse grains.

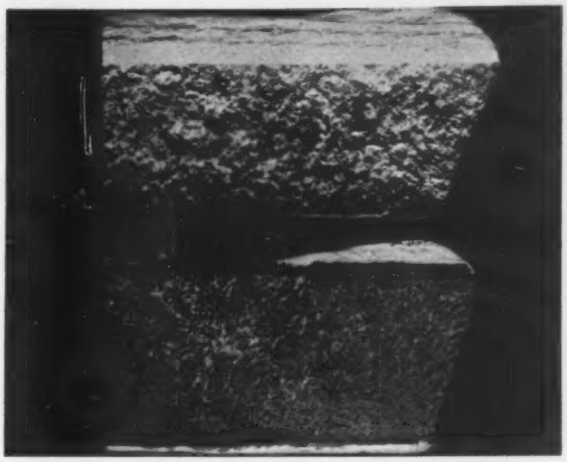

Fig. 6 — Fractured structure of aluminum-magnesium casting alloy with 5 per cent magnesium. *Top* — untreated; *bottom* — treated with carbon tetrachloride. 1 ×.

ACKNOWLEDGMENT

The author would like to thank Dr. H. Kessler and Mr. H. L. Winterstein for their assistance in carrying out the experimental work.

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6. E. Dittrich, "Die Praxis der Kornfeinung von Aluminium und Aluminium-Legierungen," *Neue Hütte, vol 3*, no. 2, pp. 93-101 (Feb. 1958).

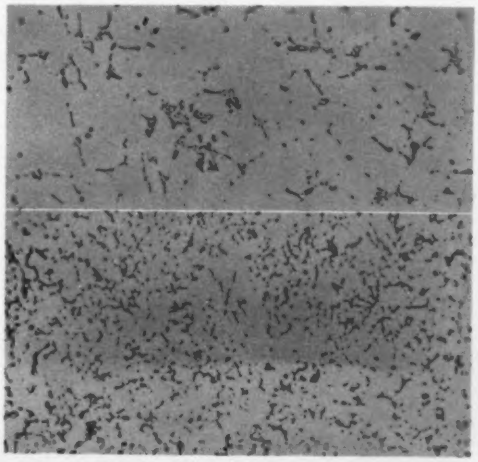

Fig. 7 — Microstructures of aluminum-magnesium casting alloy with 5 per cent magnesium. *Top* — untreated; *bottom* — treated with carbon tetrachloride. 100 ×.

HOW DO YOU KNOW IT IS DUCTILE?

by G. F. Thomas

ABSTRACT

The quality control measures used by the author's company in connection with as-cast ductile iron are outlined. The step by step procedure used includes pouring a sample from the bottom of the last pouring ladle to receive iron, checking graphite structure for vermicular graphite, pouring Y-block test castings from every tenth treatment and checking properties of test bars.

INTRODUCTION

The author's company has been producing as-cast ductile iron for approximately 2½ years. From the beginning, the company used the same method to establish acceptability of castings, that is, metallographic examination of each ladle treated. One might say that everything made is assumed not acceptable, and the quality control program is set up around this assumption. However, until some more positive or practical test is developed, present method will be continued. Briefly, the program for "knowing it is ductile" is as follows.

PROCEDURE

The company treats 1400 to 1600 lb of iron. This is transferred into one transport ladle and delivered to the foundry. Each transport ladle is tagged with a number corresponding to the number of the treatment.

Two inspectors are permanently stationed in the foundry. It is their responsibility to know the ladle number on every casting poured, and the time interval between pouring and dumping for each casting. These inspectors have no other duties and are separate from the regular quality control inspectors.

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Fig. 1 — Control micro lug core and micro lug casting.

Pouring Sample

Iron is transferred from the transport ladle to 300 lb teapot type pouring ladles. From the bottom of the last pouring ladle to receive iron, a sample measuring ½-in. wide x 1 in. high x 3 in. long is poured into an open top core. Although data to substantiate this are lean, it is felt that this sample represents that part of the treatment which would be most likely to contain the worst graphite structure (Fig. 1).

The sample is then quenched, fractured so that the final specimen is ½-in. wide x 1 in. high x 1 in. long, a flat is ground and the sample is polished through 600 grit paper by a technician. Examination of graphite structure is made at 100×. The total time between pouring and microscopic examination is of the order of 2 min. A lag of one to two treatments generally exists between knowing graphite structure and magnesium treatment.

Graphite Structure

Any trace of vermicular (or wormy) type graphite is reported immediately to the metallurgist so that corrective steps can be taken. Normally, change in graphite structure is gradual enough so that an excess of vermicular graphite can be avoided. Ten per cent of the graphite present may be vermicular and be classified acceptable. Figure 2 shows an acceptable graphite structure, and Fig. 3 shows an unacceptable structure, 20 - 30 per cent vermicular graphite.

The author's company has settled on the figure 10 per cent as a result of statistical study of the effect of vermicular graphite on predicted physical properties of ductile iron.* Figures 4, 5 and 6 show the effect of vermicular graphite on predicted tensile strength, yield strength and per cent elongation. It is obvious from these curves that up to 10 per cent vermicular graphite may be tolerated with only minor reductions in physical properties. The minimum specification in

*"Ductile Iron — As-Cast and Annealed Properties," E. McCullough, J. Peck and A. Rauch, AFS TRANSACTIONS, *vol. 67*, p. 187 (1959).

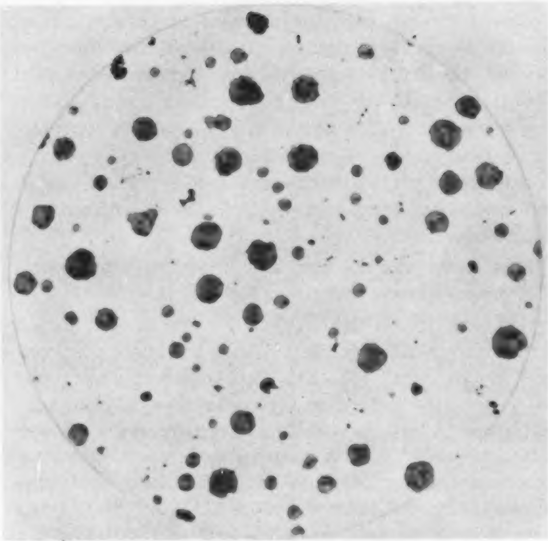

Fig. 2 — Acceptable graphite structure in control micro casting.

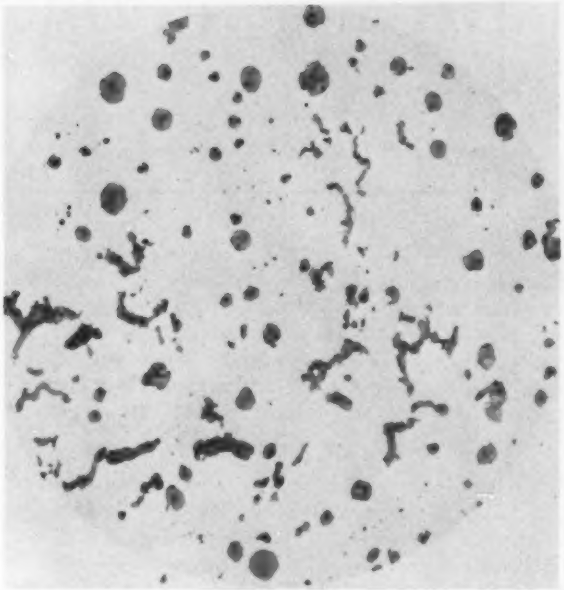

Fig. 3 — Unacceptable graphite structure in control micro casting.

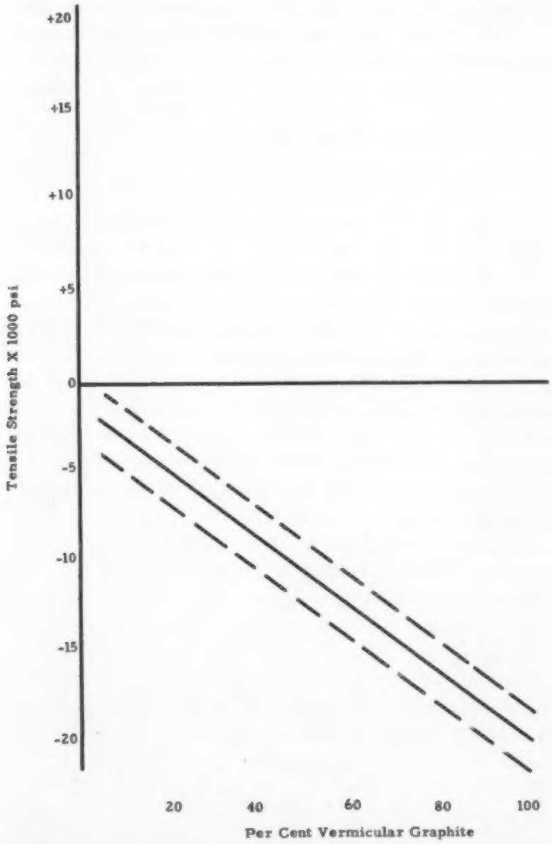

Fig. 4 — Average change in tensile strength to per cent vermicular graphite relationship in as-cast ductile iron. T.S.(psi) = -1380 − 189 (% vermicular graphite) 95% confidence limits = ±1750.

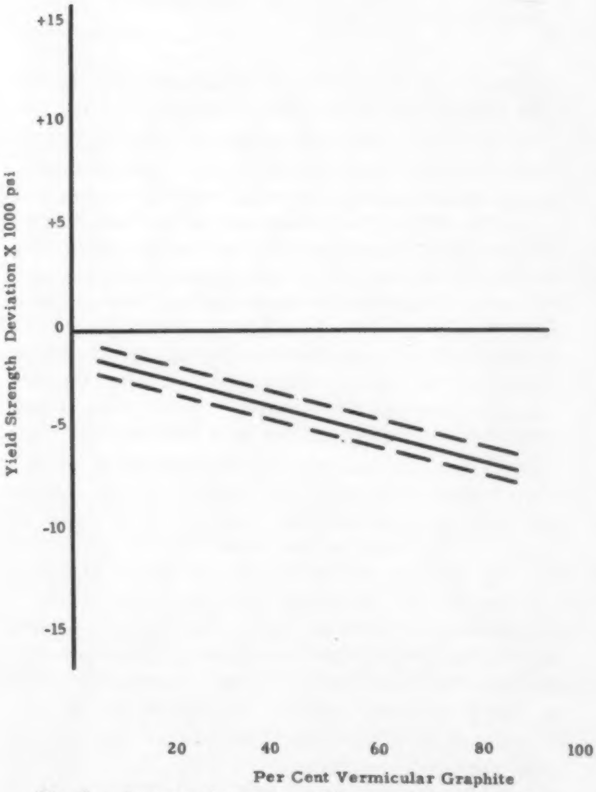

Fig. 5 — Average change in yield strength to per cent vermicular graphite in as-cast ductile iron. Y.S.(psi) = -1250 − 65 (% vermicular graphite) 95% confidence limits = ±710.

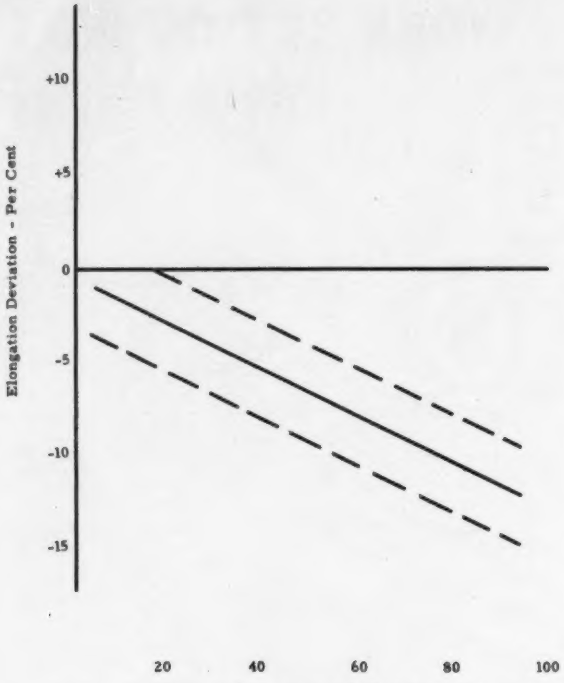

Fig. 6 — Average change in elongation to per cent vermicular graphite relationship in as-cast ductile iron. $El(\%) = -0.70 - 0.12$ (% vermicular graphite) 95% confidence limits $= \pm 2.6$.

a 1 in. Y-block is 80,000 psi tensile strength, 53,000 yield strength and 6 per cent elongation.

Should 10 per cent or more vermicular graphite be observed in the test sample, a hold is immediately placed on all castings poured from that treatment, i.e., molds are held on conveyors and are not allowed to be dumped. A small casting, poured in the vicinity of the original sample, is immediately dumped and fractured for microscopic examination. The presence of vermicular graphite in the casting is cause for all castings from this treatment to be segregated. These castings are stored for further microscopic examination at a more convenient time. Production is not delayed when this procedure is followed.

The cause for not having absolute faith in the micro examination of the test sample is quite simple. It is often the case that the sample is taken from the "dregs" or last iron in the ladle. With teapot ladles any slag will, of course, remain on top of the iron until the last iron is poured from the ladle. If slag is not covering the iron surface in the ladle, and since this top surface is constantly exposed, the magnesium on the surface could be lost as MgO, producing a film of iron that is not nodular. Slag mixed in the test sample will be black under a microscope and appear to be vermicular graphite.

Y-Block Test Castings

In addition to the control sample poured on each ladle, Y-blocks are poured from every tenth treatment. These vary from A.S.T.M. specifications in that they are 8¾ in. instead of 6 in. in length. This extra length provides a sample used for chemical analysis of the iron which is immediately adjacent to the test bar. Elements run on this sample include percentages of Mg, Ni, Si and Mn. Brinell hardness is also taken on this lug. Chilled pins are cast for analysis of per cent carbon and sulfur.

A 0.505 in. tensile bar with grip ends is cut from the bottom 1 in. of the Y-block on a tracer lathe. Tensile strength, yield strength at 0.2 per cent offset and per cent elongation in 2 in. is determined on this bar.

This completes the first and most important phase of the operation – knowing that it is ductile.

You will note, however, that only as-cast ductile iron is produced. For the castings to satisfy the hardness specification, 197 - 255 Bhn, which has been purposely set up identical to the company's pearlitic malleable iron specification, dumping time must be carefully controlled. Castings must be dumped below the lower critical temperature of 1300 F to avoid excess amounts of pearlite in the matrix. Dump times range from 30 min up to 2 hr, according to casting section size.

Originally a minimum section size of ½-in. was set up, feeling that Bhn could not be controlled on sections under this size. The popular feeling now is that these small sections may be cast providing there is no machining in that area. A casting consisting entirely of thin sections is not acceptable however, due to the probable presence of carbides.

QUALITY CONTROL CHECKS

Quality control checks are made on Bhn to determine if castings are within the 197 - 255 range. In the event castings are found above specification, the following is performed.

The casting is submitted to the metallurgist so that the cause of high hardness, either excess pearlite or the presence of carbides, may be determined. With excess pearlite, castings are given a sub-critical anneal at 1250 F for 2 - 3 hr and slow cooled. With carbide, castings are annealed at 1700 F for 2 - 3 hr.

Soft castings are also rejected due to the low physical properties that accompany low hardness. Soft castings are normalized at 1650 - 1700 F, air quenched and then drawn back to the desired hardness.

Of the three heat treatments noted above, the most common is the sub-critical anneal; the cause in most cases being fast dump times. The problem revolves around balancing mold production, conveyor space, dump time and melting rate. To emphasize this point, an example might be worth while. One particular job made on small cope and drag machines required 4 roller conveyors when it was made in pearlitic malleable iron. The job is now ductile iron and requires 6 roller conveyors. Every effort is made to have high mold production, long dump time jobs poured up as tight as possible to avoid loss of mold production. All of these efforts are made for one purpose – to avoid premature dump time and hard castings.

FLUIDITY OF 85-5-5-5 AND COMPOSITION M METAL

by R. A. Rosenberg, H. D. Brody and F. C. Monkman, Jr.

ABSTRACT

The vacuum fluidity test was employed to determine the effect of superheat and metal head on the fluidity of 85-5-5-5 and Composition *M* Metal. For equal superheat 85-5-5-5 exhibits less fluidity than Composition *M* Metal. The fluidity of 85-5-5-5 was doubled and Composition *M* Metal tripled with 400 F superheat. Experiments showed that at 2250 F the fluidity of 85-5-5-5 increased by about 90 per cent for metal heads between 15.7-32.7 in. of liquid copper.

The effect of various mold coatings on alloy fluidity was also studied, by employing double spirals cast from the same gating system. 0.004 in. coatings of hexachloroethane and $SnCl_2$ on sand molds increased the fluidity of 85-5-5-5 and Composition *M* Metal by 300-50 per cent between pouring temperatures of 2025 F and 2100 F. Lamp black was more effective than hexachloroethane or $SnCl_2$ in increasing the fluidity of 85-5-5-5 above 2100 F and Composition *M* Metal at pouring temperatures greater than 2200 F. The insulating properties of the mold coatings account for any increase in metal fluidity.

INTRODUCTION

Foundrymen often experience difficulty in pouring thin walled or intricately shaped castings. Either the castings do not fill completely or their strength is lowered by cold shuts and uncontrolled shrinkage. In bronze alloys used as valve materials designs previously thought too difficult to produce by foundry techniques may be possible if the fluidity characteristics of the alloys and the influence of mold coatings on metal fluidity were understood.

Fluidity, in the foundry sense, is the ability of molten metal to fill a mold. It can also be defined as the distance that liquid metal flows in some standard mold cavity. The foundry definition of fluidity should not be confused with the more precise physical definition of fluidity, 1/viscosity. Fluidity, by the physical definition, is a unique physical constant of a metal at a certain temperature. In foundry terminology it is a complicated concept dependent not only a) on the metal concerned, but also on b) the mold materials, c) the mold shape and d) the pouring conditions.

"Composition *M*" and "85-5-5-5" are common valve materials, but fundamental knowledge of the fluidities of the above alloys is limited. Therefore, experimental work was carried out to determine the effect of superheat and pressure head on the fluidities of the two alloys by employing the vacuum fluidity test.[1] Second, work was also performed in order to observe the influence of various sand mold coatings on the fluidities of the above alloys.

LITERATURE REVIEW

In order to study the fluidities of metals and alloys, and to be able to understand and predict the factors which affect fluidity, several tests have been devised to measure the ability of molten metal to fill standard test molds. The earliest test was employed to measure the fluidity of commercial cast iron.[2] The distance that cast iron filled an elongated horizontal wedge was taken as a measure of fluidity. Ruff[3] poured metal into a long thin cylindrical channel molded in sand. The channel was difficult to keep level and it was hard to prevent a mismatch of the mold. Here again though, fluidity was defined as the length to which the channel completely filled before the metal solidified.

A U-shaped test mold has also been used.[4] In this test metal flows along a runner and into several vertical tubes of various cross-section. The height to which the tubes fill is the measure of fluidity. For those alloys having high fluidity, the height of the tube of smallest cross-section is measured. For low fluidity metals the height of the tube of largest cross-section is used as the measure of fluidity.

Saito and Hayashi[5] made the long thin channel test more suitable for foundry application by bending the channel into a spiral. Since then, the fluidity spiral has become the most popular type of fluidity test and numerous modifications of the original mold design have been used; the cross-section of the spiral has been circular, semicircular, rectangular or trapezoidal, depending on the surface to volume ratio desired.

Several researchers have studied the effect of chemistry on the fluidity of red brass by employing the spiral test specimen.[6,7] Halliwell[8] also applied the fluidity spiral and noted the importance of metal head on the fluidity of bronze alloys.

Flemings et al[9] employed a double spiral to study the effect of various mold coatings on the fluidity of aluminum alloys. Two spirals were fed from a common gating system. Only one spiral was treated and the lengths to which each spiral filled

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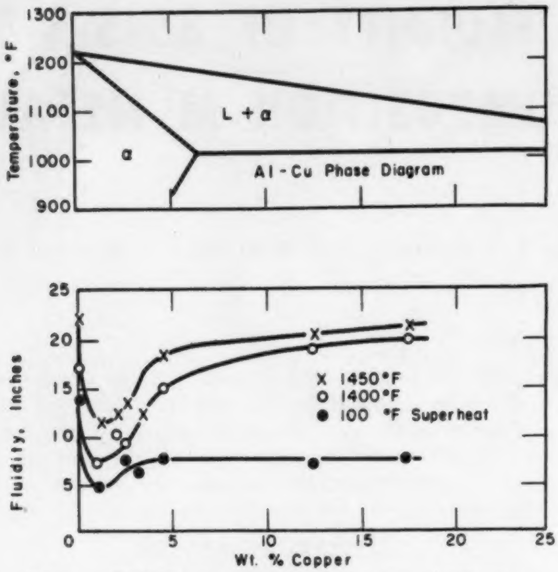

Fig. 1 — Fluidity vs. composition for the aluminum-copper system at various pouring temperatures (Flemings, et al[9]).

was compared. The same test method was utilized by filling two thin plates from a common gating system and comparing the volumes of metal that filled each plate after one-half of the mold was treated.

Vacuum Fluidity Test

Ragone et al[1] designed a vacuum fluidity test method which is capable of applying an instantaneous pressure head. Low melting point alloys were made to flow directly from a crucible into pyrex tubes by a partial vacuum applied at the free ends of the tubes. They were able to study the important metal variables in fluidity and to predict the fluidity from quantitative calculations. Other investigators have used this method in determining the fluidity of light metal alloys.[10,11,12] The disadvantage of this test, from the practical foundryman's viewpoint, is that it does not permit the study of the effect of mold or mold-metal variables on fluidity. However, the test is ideal for investigating the effect of metal solidifcation variables on fluidity.

The relationship of superheat and composition to fluidity is shown in Fig. 1. Obviously, the hotter the metal when poured, the longer it takes for the metal to cool to temperatures at which it can no longer flow. The fluidities of pure metals have been found to double, and the fluidities of alloys have been tripled, with an increase of only 200 F superheat.[12]

Fluidity varies inversely with the freezing range of the alloy. The greater the temperature range between the start and end of solidification, the less the fluidity. This dependence on composition is due to the different manner of solidification of metals having short freezing ranges and alloys with large freezing ranges.[10,11,12] Therefore, for equal superheat fluidity is a maximum for pure metals and eutectic compositions.

The insulating ability of molds is important when considering metal fluidity. If the mold is insulating freezing and stoppage of flow will be delayed. Moisture content and mold facings are also important for their insulating abilities. Flemings et al[9] demonstrated that a thin coating of hexachloroethane on the mold surface tripled the fluidity of aluminum, because it provided an insulating layer of chlorine gas between the metal and mold.

METAL FLUIDITY

In place of a spiral mold to measure metal fluidity, a vacuum fluidity test has been developed whereby an instantaneous metal head can be applied.[1] This test eliminates sand mold and mold-metal variables, and presents an opportunity to study the effect of just metal solidification variables on fluidity.

EXPERIMENTAL PROCEDURE

Twenty-five lb of 85-5-5-5 or Composition *M* ingot were melted in an MgO crucible set in a 30 lb capacity 20 kw induction furnace. Zinc losses during melting were compensated for by adding 2 oz of zinc for each 25 lb of ingot melted prior to deoxidizing with copper-15 per cent phosphorus shot.

Temperatures were recorded with a platinum-platinum 10 per cent rhodium thermocouple protected with a silica sheath. The temperatures were read from a Leeds-Northrup recorder which was checked with a Brown potentiometer before and after each experiment.

A partial vacuum was produced in a Bell jar by a water pump aspirator and the pressure difference measured on a mercury manometer. The top of the jar was sealed with a rubber stopper coated with a viscous salve. The bottom was sealed with a ⅛-in. thick rubber sheet coated with salve.

The metal was brought to some high temperature (2375 F) and allowed to cool in the crucible. At several predetermined lower temperatures a vycor tube (0.150 in. I.D.) connected to the Bell jar was dipped into the melt below the slag, and the pinch cock opened allowing the metal to fill the tube to some distance (Fig. 2). The vacuum (pressure head) was checked with a mercury manometer calibrated in in. of liquid copper and the used tube was replaced. A "head" of 19 in. of liquid copper was maintained throughout all of these experiments. The melt cooled to the next desired lower temperature and another sample was taken in the manner described above. Using this procedure, five to eight fluidity samples were obtained with each heat before the metal was finally pigged.

Fluidity Channel Analysis

Chemical analyses were obtained after each heat from drillings of melt samples and from fluidity specimen slices. Analyses of the fluidity channels were made from ½-in. long sections taken at several locations along the specimen length.

The pressure head was measured with a mercury manometer and converted to in. of liquid copper by use of the equation:[1]

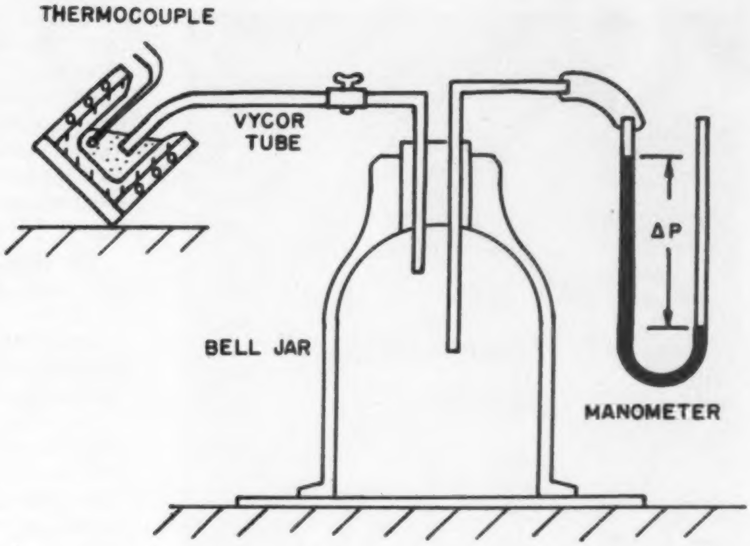

Fig. 2 — Schematic diagram of equipment used to measure metal fluidity by vacuum fluidity test.

$$\Delta P_{Cu} = \Delta P_{Hg} \frac{\rho H_2}{\rho Cu} - \Delta Z$$

where

ΔP_{Cu} = metal head in inches of liquid Cu.
ΔP_{Hg} = pressure difference in inches of Hg.
ρHg = density of Hg.
ρCu = density of liquid Cu.
ΔZ = difference in height of metal in crucible and level part of tube.

Superheat Effect

The length to which the vycor tubes filled in the vacuum fluidity tests is considered as the measure of alloy fluidity. Fluidity vs. temperature for 85-5-5-5 and Composition *M* are plotted in Fig. 3. The curves show that the fluidity of Composition *M* Metal is tripled and the fluidity of 85-5-5-5 is doubled with 400 F superheat. Between 2100 F and 2200 F the fluidity of 85-5-5-5 increases 18 per cent, and that of Composition *M* increases 25 per cent. Thus, in the temperature range of practical importance, it pays to pour the alloys quickly before they can cool.

Metal Head Effect

The fluidity of 85-5-5-5 at 2250 F increased about 90 per cent when the metal head, converted to inches of liquid copper, was doubled. The results of the test are plotted in Fig. 4 for metal heads of 15.7 to 32.7 in. of copper. The apparatus used was not suitable for studying smaller metal heads, but it is expected that fluidity would increase slightly more rapidly with only small increases in pressure for metal heads below 15.7 in.

A foundry may reduce its scrap loss on a casting that is prone to misrun by utilizing the effect of pressure on fluidity. An upset could be placed on the cope in order to increase the sprue height a few inches. Bottom pour ladles would be useful here also; or a pouring basin made of core sand might be placed on top of the cope to allow not only for a greater metal head, but also a smoother flow. Also pouring fast would build up the metal head more rapidly, and thus help fill the mold cavity completely.

MOLD COATINGS

The standard double spiral and plates employed by Flemings et al[9] was used to study the effect of various molds coated with hexachloroethane (a chlorinated hydrocarbon), $SnCl_2$ and lamp black on the fluidities of 85-5-5-5 and Composition *M* Metal. Figure 5 shows two spirals 28 in. long having a rectangular cross-section, 0.50 in. wide and 0.125 in. thick, which were fed from a common gating system. Both spirals were molded in the cope. The 10 in. runner, with a 1.0 x 0.50 in. rectangular cross-section was molded in the drag.

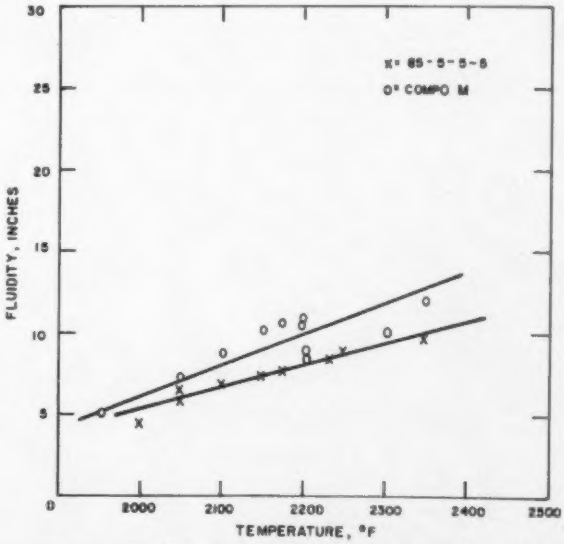

Fig. 3 — Fluidity of 85-5-5-5 and composition *M* metal as a function of temperature (obtained by using vacuum fluidity test).

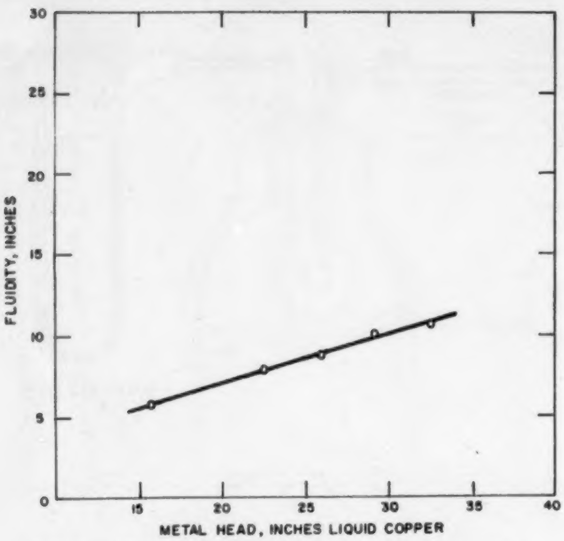

Fig. 4 — Fluidity of 85-5-5-5 as a function of metal head measured in inches of liquid copper at 2250 F.

The large runner served to minimize turbulence and dross, and ensured that a constant head would be attained before metal entered the spirals. The fluidities of the coated and uncoated spirals are easily compared after casting the alloy through the common gating system. The relative increase in metal volume due to the mold coatings can also be seen when double plates are cast with a common gating system.

EXPERIMENTAL PROCEDURE

In this phase of the work all of the molds were hand rammed in regular 17 in. x 12 in. flasks. The molding material used was synthetically bonded green sand (washed and dried Marion Sand AFS 95-105). The moisture content averaged 4.0 per cent. Vent holes (½-in.) were provided at the end of each spiral to permit the escape of mold gases. When molding double plates, six vent holes were incorporated into the mold at the farther end of each plate. A pouring basin also was incorporated in the mold in order to maintain a constant metal head when pouring.

The cope and drag sides of one of the double spirals were treated with hexachloroethane (C_2Cl_6), $SnCl_2$ or lamp black. C_2Cl_6 was either sprayed or dusted onto the mold surfaces through a 200 mesh screen just before closing the cope and drag. The $SnCl_2$ and lamp black were dusted on. When spraying C_2Cl_6 onto the mold a spray was prepared by dissolving C_2Cl_6 crystals in ether. The resulting solution was then applied to the mold surface with a spray gun. The ether immediately volatilized leaving a white coating of C_2Cl_6 on the mold surface. The coating thickness was determined by placing a thin flat plate next to the surface being sprayed and measuring the increase in thickness of the coated plate with a micrometer. Coating thickness averaged 0.004 in.

Thirty lb of Composition *M* or 85-5-5-5 ingot were melted in a clay graphite crucible set in a 175 kw lift coil induction furnace of 150 lb capacity. 2½-oz zinc was added during melting for compensation of zinc losses, and the heats were deoxidized with copper-15 per cent phosphorus shot prior to pouring.

The metal was heated to about 2350 F, and five double spirals were rapidly poured at various temperatures as the melt cooled. Temperatures were read with a chromel-alumel thermocouple sheathed in a graphite tube, and connected to a Leeds-Northrup recording device which was checked before each heat with a Brown potentiometer. After the molds were shaken out, the relative increases in fluidity due to the mold

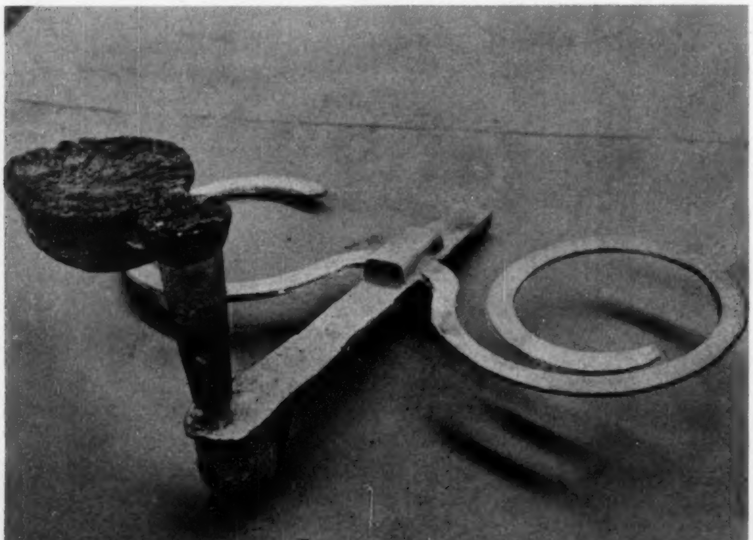

Fig. 5 — 85 5-5-5 double spiral fluidity casting showing gating system used. Control spiral is at left and spiral coated with lamp black is at right.

coatings were recorded by measuring the lengths of the coated and uncoated spirals (Fig. 6). Double plates were cast in the same manner after coating one plate with C_2Cl_6. The relative increase in metal volume due to the mold coatings was easily seen (Fig. 7).

Experiments were also performed by dusting the material onto mold surfaces instead of spraying it on. When dusting $SnCl_2$ and lamp black onto the mold surfaces coating thicknesses were measured in the manner described above.

RESULTS

Figures 8 and 9 are plots of fluidity vs. pouring temperature for the uncoated halves of the double spirals when cast with Composition *M* Metal and 85-5-5-5. Fluidity increases linearly with pouring temperature in both cases, but 85-5-5-5 exhibits less fluidity than Composition *M* Metal for equal superheat.

The effect of hexachloroethane and $SnCl_2$ coated molds are shown in Figs. 10 and 11. There was no appreciable variation in fluidity when C_2Cl_6 was either sprayed or dusted onto the mold surfaces.

Figures 12 and 13 show the effect of lamp black mold coatings on the fluidities of Composition *M* Metal and 85-5-5-5.

At pouring temperatures between 2025 F and 2100 F molds coated with C_2Cl_6 or $SnCl_2$ increase the fluidity of Composition *M* Metal and 85-5-5-5 from 300-50 per cent. The effectiveness of the coatings decreases rapidly at pouring temperatures greater than 2100 F (Fig. 14).

Lamp black increases the fluidity of Composition *M* Metal at pouring temperatures greater than 2200 F. However, at temperatures below 2150 F, lamp black is ineffective in aiding the fluidity of this alloy (Fig. 14).

Figure 14 also shows that lamp black is more effective in increasing the fluidity of 85-5-5-5 than C_2Cl_6 or $SnCl_2$ at temperatures above 2100 F. At pouring temperatures below 2100 F molds coated with C_2Cl_6 or $SnCl_2$ are more efficient than lamp black in increasing the fluidity of 85-5-5-5.

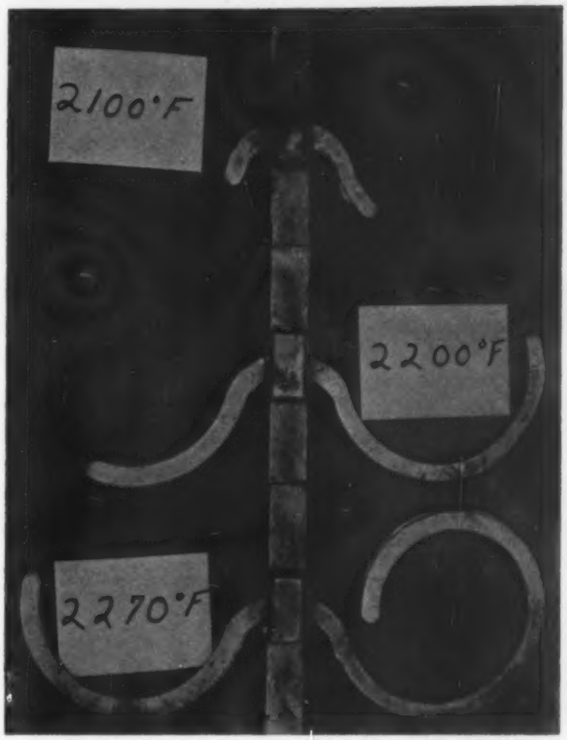

Fig. 6 — Relative increase in fluidity of 85-5-5-5 at various pouring temperatures due to lamp black coated sand molds. The treated half of the test molds are at right; the untreated control spirals are at left.

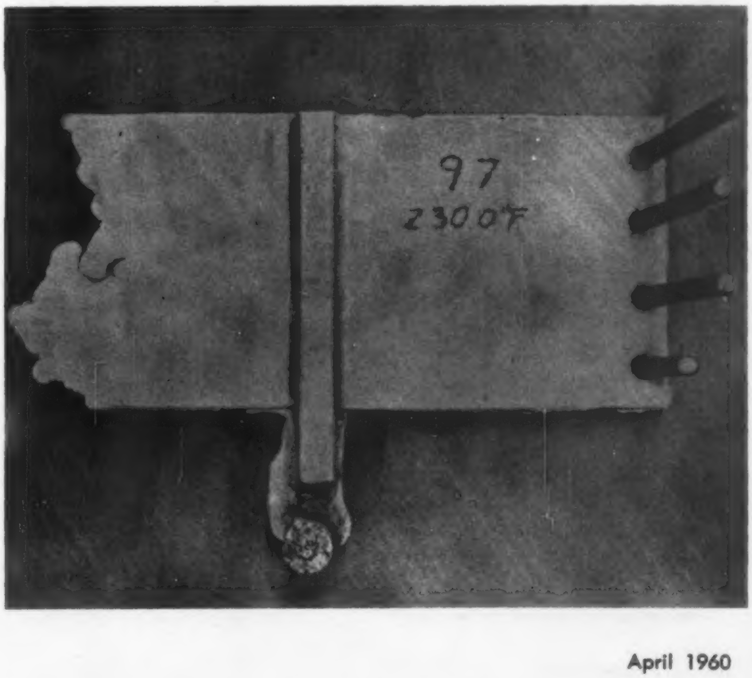

Fig. 7 — Relative increase in volume of composition *M* metal due to coating part of sand mold with C_2Cl_6. Plates were 1/8 x 9 x 8 in., and were fed from a common gating system. The untreated control plate is at left. The mold at right was treated with a 0.004 in. C_2Cl_6 coating.

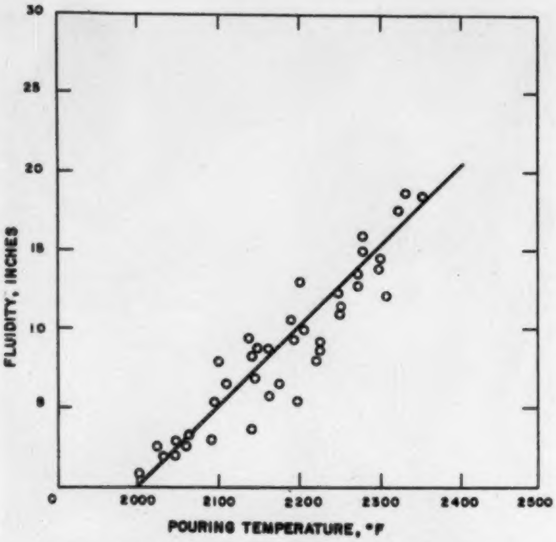

Fig. 8 — Fluidity of composition *M* metal vs. pouring temperature for the uncoated control spiral.

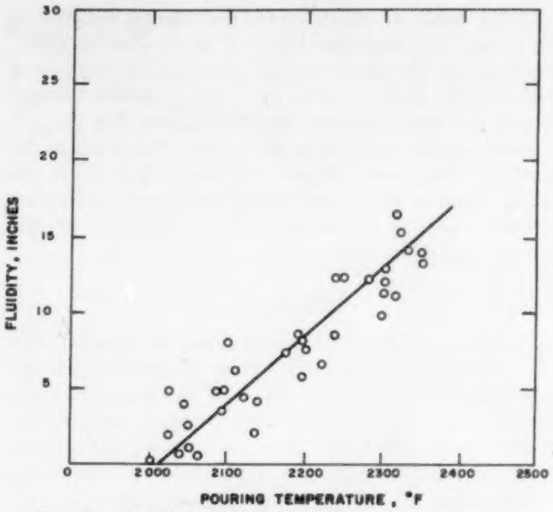

Fig. 9 — Fluidity of 85-5-5-5 vs. pouring temperature for the uncoated control spiral.

DISCUSSION

Flemings et al[9] theorized that the chlorine gas, generated by contact of molten aluminum with hexachloroethane mold coatings, produced an insulating atmosphere between the metal and mold. Thus, the liquid metal retained its heat longer and therefore ran farther. Since hexachloroethane sublimes at 560 F, it was felt that the generated gas might dissipate and be less effective when pouring bronze alloys from 2200 F than when casting aluminum.

Therefore, molds were coated with $SnCl_2$, which generates chlorine at a higher temperature (1154 F).

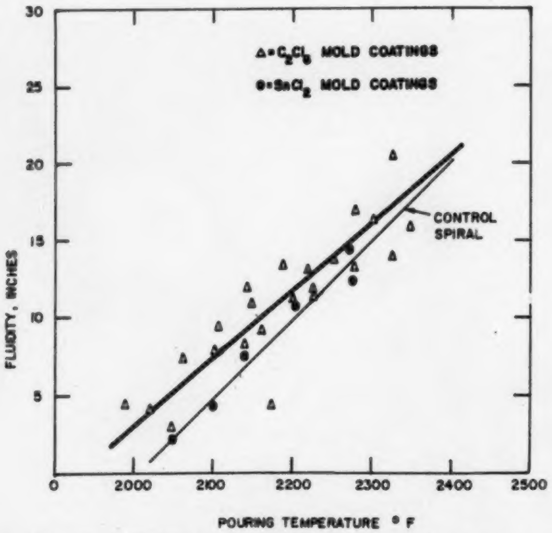

Fig. 10 — Fluidity of composition *M* metal vs. pouring temperature for spirals coated with C_2Cl_6 and $SnCl_2$. The increase in fluidity due to the mold coating is compared to the fluidity of the alloy cast into the uncoated control spiral.

Results showed that the chlorine generated from either compound is equally effective at the pouring temperatures studied, since no appreciable variation in metal fluidity was noticed.

Lamp black an amorphous carbon used by foundrymen as a mold coating for centuries is an effective insulator. Its fine feathery nature contributes to its thermal insulating properties. The thermal conductivity of lamp black is more than 100 times less than that of carbon. Therefore, it was originally expected that lamp black would greatly influence fluidity at all pouring temperatures studied.

The results show that for pouring temperatures below 2150 F the chlorine generating compounds increase fluidity to a greater degree than lamp black coated molds. At higher pouring temperatures lamp black was more effective in increasing metal fluidity than C_2Cl_6 and $SnCl_2$. This is probably due to the dissipation of the chlorine atmosphere, which decreases in insulating ability with increasing metal temperature.

Alloy Chemistry Influence

Perhaps the most important factor influencing variation in the results is alloy chemistry. The material used was melted in the form of commercial ingots. Specifications call for chemistries which can vary as much as 3 per cent in alloy content.

	Composition M	85-5-5-5
Copper, %	86.0 - 89.0	84.0 - 86.0
Tin, %	5.5 - 6.5	4.0 - 6.0
Lead, %	1.0 - 2.0	4.0 - 6.0
Zinc, %	3.0 - 5.0	4.0 - 6.0
Nickel, %	1.0 max.	1.0 max.
Iron, %	0.25 max.	0.30 max.
Phosphorus, %	0.05 max.	0.05 max.

Fluidity can be affected by small variations in the lead or phosphorus content since these elements can

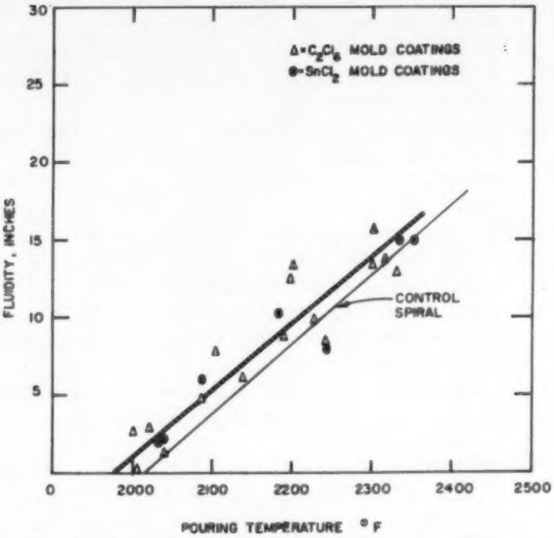

Fig. 11 — Fluidity of 85-5-5-5 vs. pouring temperature for spirals coated with C_2Cl_6 and $SnCl_2$. The increase in fluidity due to mold coating is compared to fluidity of the alloy cast into the uncoated control spiral.

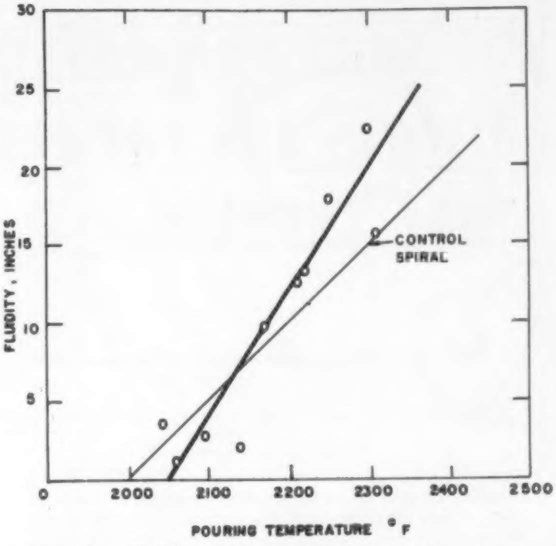

Fig. 12 — Fluidity of composition *M* metal vs. pouring temperature for spirals coated with lamp black. Increase in fluidity due to mold coating is compared to the fluidity of the alloy cast into uncoated control spiral.

exist as liquid at relatively low temperatures. Commercial ingots were used, however, so that the work more closely represented common foundry practice. Therefore, the data obtained are meaningful to the practical foundryman.

It has been shown that fluidity is a function of coating thickness also.[9] Difficulties in applying even coatings were encountered, and this no doubt caused scatter in fluidity results especially when the compounds were dusted onto the mold surfaces.

Castings produced in molds coated with C_2Cl_6 and $SnCl_2$ resulted in discolored surfaces. The discoloration was removed by sand blasting. It was also noticed that if the molds were not sufficiently permeable, or if a vent was not incorporated in the mold, the cast fluidity spirals exhibited dished or gassy surfaces due to the evolution of chlorine. This was eliminated when proper venting was employed.

Molds coated with lamp black produced castings with rougher surfaces than the uncoated molds. However, sand blasting reduced surface roughness considerably.

Since the coating thicknesses are measurable, they would detract from the dimensions of any casting.

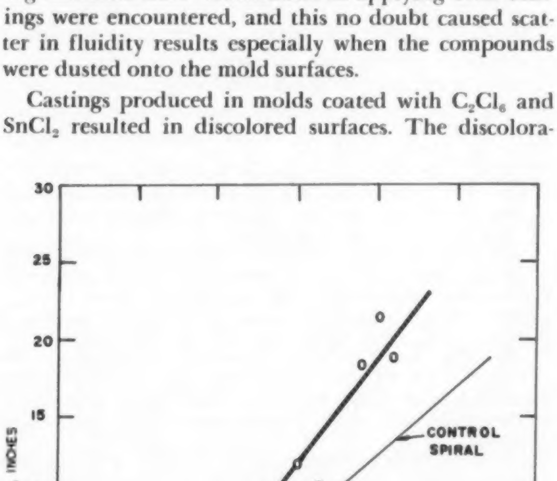

Fig. 13 — Fluidity of 85-5-5-5 vs. pouring temperature for spirals coated with lamp black. Increase in fluidity due to mold coating is compared to fluidity of alloy cast into uncoated control spiral.

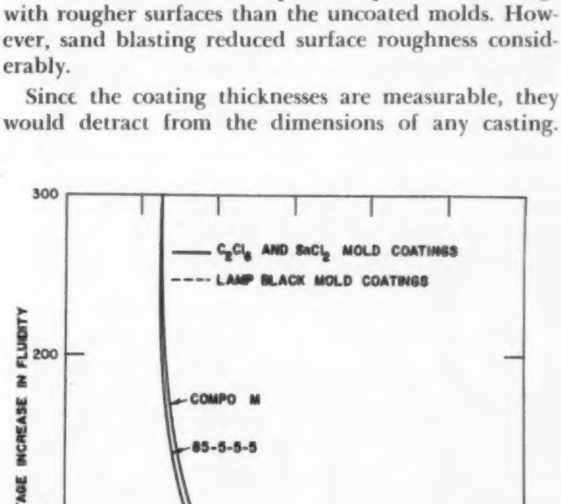

Fig. 14 — Percentage increase in fluidity due to various mold coatings vs. pouring temperature for 85-5-5-5 and composition *M* metal.

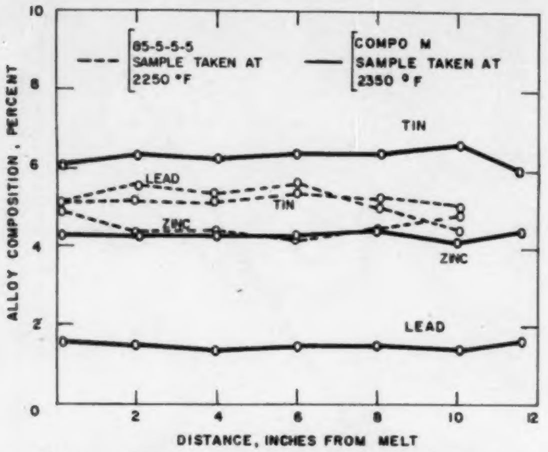

Fig. 15 — Composition of lead, tin and zinc along the lengths of two vacuum fluidity specimens. 85-5-5-5 sample was taken at 2250 F and composition *M* metal at 2350 F.

Therefore, in the design of patterns tolerances should be allowed for coating thickness.

Porosity and Shrinkage Effect

Shrinkage and porosity no doubt influence metal fluidity. Several vacuum fluidity samples were sectioned and polished, and some porosity was exhibited after etching. After examination it was decided that the shrinkage and porosity obtained during the course of the research was not sufficient to appreciably affect the results. Second, the methods used in this study are similar to conditions experienced in commercial practice, and therefore the results are directly applicable to common foundry practice.

Raising the temperature of the heats to 2350 F could permit zinc to escape faster and allow for absorption of gases. These facts could account for some variation in the results. However, analyses taken along the length of several vacuum fluidity test specimens indicated that if there was any loss of zinc at elevated temperatures it was low, because the zinc contents fell within commercial limits (Fig. 15).

A practical method for increasing the fluidity of 85-5-5-5 and Composition *M* Metal is to dust fine lamp black onto the sprues, gates and risers. The material could be applied by dusting it through a fine meshed bag onto the mold. The increase in fluidity would not be exceptionally great, but in many cases the effect of insulating the gates and risers could be enough to overcome previous insufficient metal fluidity.

CONCLUSIONS

1) For equal superheat 85-5-5-5 exhibits less fluidity than Composition *M* Metal.
2) The fluidity of 85-5-5-5 is doubled and Composition *M* Metal tripled with 400 F superheat.
3) The fluidity of 85-5-5-5 increases 18 per cent between 2100-2200 F.
4) The fluidity of Composition *M* Metal increases 25 per cent between 2100-2200 F.
5) At 2250 F the fluidity of 85-5-5-5 increases about 90 per cent for metal heads between 15.7-32.7 in. (inches of copper).
6) Hexachloroethane and $SnCl_2$ coated molds increase the fluidity of Composition *M* Metal by 300 per cent at 2025 F and by 35 per cent at 2150 F.
7) Hexachloroethane and $SnCl_2$ coated molds increase the fluidity of 85-5-5-5 by 300 per cent at 2025 F and by 30 per cent at 2150 F.
8) Lamp black increases the fluidity of 85-5-5-5 by 50 per cent at pouring temperatures between 2100 and 2300 F.
9) Lamp black effectively increases the fluidity of Composition *M* Metal at pouring temperatures in excess of 2200 F.
10) Hexachloroethane and $SnCl_2$ are most effective in aiding the fluidities of 85-5-5-5 and Composition *M* Metal at pouring temperatures below 2150 F.
11) The increase in metal fluidity is a result of the insulating properties of the mold coatings.

ACKNOWLEDGMENTS

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PATTERN AND CORE BOX EQUIPMENT FOR BLOWING FOUNDRY SANDS

venting and design

by Z. Madacey

ABSTRACT

Important factors in the venting and design of pattern and core box equipment are reviewed by the author. Less venting is required for the more flowable sands, and conversely greater vent area is required when using sand of high green strength. The faster the air required to move a given volume of sand into the core box cavity escapes, the greater is the sand impact in the core box and the greater is the core density. Blow hole and vent diameter used to accommodate the air needed to move the sand determines the density and quality of the mold or core being blown.

INTRODUCTION

Recently figures of tremendous magnitude have been brought to light in the foundry industry. These figures represent specific investments made by the industry over the past ten years. Two of the most important of these fields of investment were mechanization and modernization. These were made for the purpose of eliminating the drudgery of foundry operation and to improve our product physically and chemically while giving it greater dimensional accuracy.

As foundry equipment manufacturers the author's company naturally is interested in the day to day trends of our industry. It is rather interesting to note therefore, that while tonnage has increased, the number of foundries in the United States and Canada has decreased approximately 4 per cent. Statistics reveal that the increased tonnage is attributed to the increase in automation and mechanization in the industry. Almost without exception the foundries that have closed their doors are the ones that have failed to recognize the importance and necessity of mechanization to be competitive in price and quality.

Investigation of various mechanization programs shows that there were more blowers purchased by the foundry industry during 1958 and 1959 than during any like period of the past. Previously foundrymen thought that only the select few highly specialized production foundries could economically produce quantity and quality cores of various sizes and shapes. This is no longer true. This new blowing equipment is now responsible for numerous semi-production and jobbing foundries reporting increased quantity and types of cores now being blown.

Although it is not felt that the blowing of sands for any one of the number of processes (shell, CO_2, resin bonded sands or molding sands) is the answer to all of the foundry's ailments, it is felt that if properly practiced it can be a step in the right direction. In the majority of castings, coring the holes and cavities is much more important and costly than are the outside surfaces.

It has been the author's company's observation through years of experience that the successful practice of blowing sand consists of a number of major factors which this discussion will endeavor to consider.

RIGGING BOXES FOR SAND BLOWING MACHINES

The pattern maker and the maintenance man (while they are sometimes taken for granted) are much more of a factor in the economical and successful operation of blowing sands than is realized. This fact is evidenced everyday by the gunny sacks, canvas and steel screens that surround blowers to prevent sand that is coming through the joints of the core boxes and seals of the magazine from injuring the operator and his fellow employees. These conditions can be controlled by proper rigging.

In some cases this condition comes about by operators attempting to blow core boxes with greater surface area than that for which the machine was built. This causes the box to separate at the joint or sand magazine seal. Some blowing machines are designed and rated with more vertical clamping pressure (force to hold the box together during the blow) than internal blow pressure in the cavity of the core box while the core is being blown. In most cases, however, it is a matter of the core box equipment being properly rigged for the green properties of the sand and the density of the core required.

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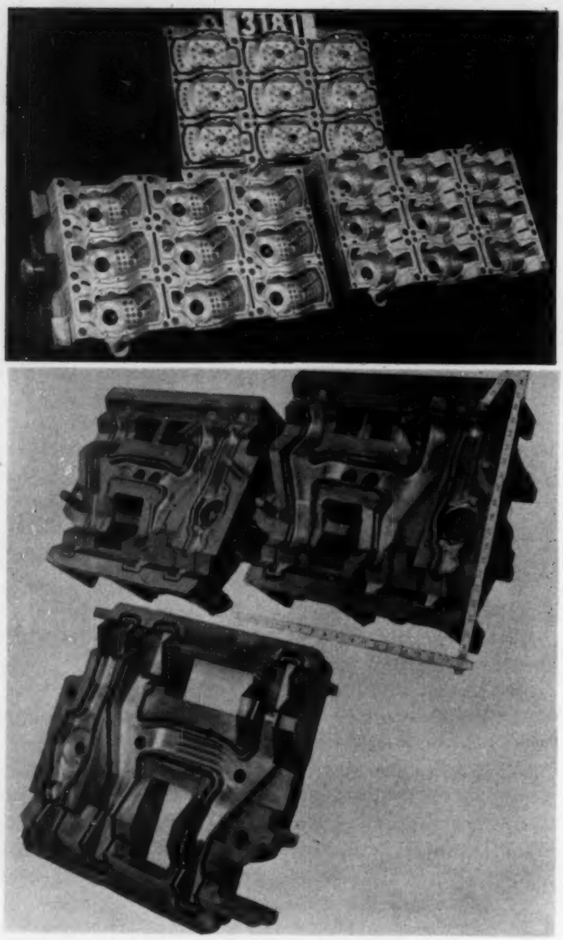


Fig. 1 — Examples of sealed core box which prevents frequent major repairs and improves core quality. Blowing out of sand at the joints is eliminated.

Another of the qualities required of the manufacturer of core-blowing machines is parallelism between the table and the blow plate. Parallelism of the parting lines, (the top and bottom surfaces) are measures of the quality of the core box manufacturer. Parallel surfaces are essential for the sealing of mating surfaces.

It is the author's company's opinion that to assume responsibility for rigging core boxes and patterns for blowing, the craftsman must first know the fundamentals and the basic principles of blowing. Only then can correct sizes and vent areas (slot type, metal, plastic or screen) be installed—and in the correct locations.

Generally, slotted vents are used on casting surfaces of the core and leave a minimum blemish. Screen vents are used on core prints or unimportant surfaces of the core. For a given diameter, screen vents exhaust more air than do the slotted type.

Blow holes and agitators are equally important. Correct sizes of blow holes, various shapes and proper locations can only be arrived at when the sand properties are known. It must also be determined whether or not agitators are to be used in the sand magazine. They definitely have a bearing on the proper rigging.

Where air gets through the vents a portion of the fines in the sand are bound to get through. The operator should be protected against this, but the need for screens of any type around the machine can be definitely eliminated by proper rigging.

Proper Sealing

In high production core boxes and patterns proper sealing is a must. The most careful core blower operator will, when working with sand, leave sand grains in sufficient numbers on the partings to cause the sand to blow out. First the air blows out of the natural vent provided by the sand grains at the joints; then the fines follow and eventually the larger grains, which act as abrasives. Within a matter of hours major repairs are required on the partings of the core boxes. This is especially true on the irregular partings.

Figure 1 shows an example of a properly sealed core box. When the core box is thus sealed, it not only prevents frequent major repairs, but it also improves the quality of the core and eliminates completely the blowing out of sand at the joints of the core box. It is a definite safety factor.

It is a good policy for the craftsman rigging the core boxes to be ever mindful of the fact that proper operating procedures dictate that the core surface area should not exceed that of the diaphragm or piston in the vertical clamp, depending upon the type of blower being used. This problem can be partially overcome by using the vent area in the core box pattern and blow plate. The combined vent area determines the percentage of core box or pattern surface area that can be overcome.

It is important also to note that core boxes must be designed and constructed so that there is sufficient area for the installation of proper seals. Equipment that has served for years on other types of core making machines or benches can, and have in many cases, been successfully rigged for blowing. This also includes sealing. The fact still remains, however, that equipment can best be rigged for quality and quantity if started from the blueprint itself. This is especially true for high production core box and pattern equipment.

Venting

Figure 2 shows a well vented core box and a poorly vented core box. We believe that proper design and construction of most core boxes can be controlled by the study of this drawing.

This illustration shows the air entering through the blow valve at 100 lb pressure. Although the figures are estimated, the author's company has through experience come to the conclusion that as the air flows through the distributing plate the pressure drops to approximately 95 lb/sq in. Air, taking the path of least resistance, flows through the blow holes into the core box cavity.

At this point it again drops to approximately 80 lb/sq in. As it deposits the sand in the core box or

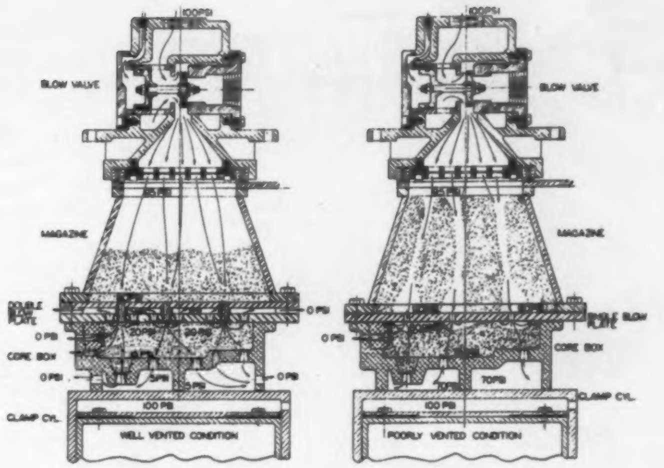


Fig. 2 — Example of well vented (left) and poorly vented (right) core box.

flask cavity, it then proceeds through the vents to the atmosphere and the pressure drops to zero. The greater the vent area, the faster the air gets to the atmosphere, the faster the sand is deposited and the denser the mass. This occurs as shown on the left-hand side only when the core box is properly constructed and the blow plate properly rigged for blowing.

In the right-hand figure we see a similar condition with two exceptions. First, it is, in relation to the left-hand figure, a poorly vented core box. Second, a single blow plate is used with blow holes in it only, and no vents. This results in the volume of air that is required to fill the core box cavity not being able to get through the vent area.

Pressure Buildup

Box pressure is subsequently built up in the blow hole area, and when this pressure in the core box becomes equal to the pressure on the topside of the blow plate a channeling condition is experienced, such as shown in this figure. This condition is often attributed to a number of things. Actually, it is simply a matter of insufficient vent area to accommodate the volume of air required to move the sand into the core box cavity through the sizes of blow holes provided.

It is logical to assume from the above description that the air is being used as a vehicle to carry the sand into the core box cavity, and that the size of the blow holes provided determines the velocity with which this is accomplished. If the density of the core required does not need the velocity in this illustration, the blow holes can then be increased in area. Through experience it has been found that the larger the blow hole area, the less the volume of air required to move a given amount of sand.

As a matter of illustration, the hole in the blow plate is increased to almost the size of the core box. As the blow valve is actuated and air rushes through the distributing plate and the sand magazine the sand would have a tendency to move. This is due to the air pressure applied at the top of the mass or all around the mass, depending upon the type of sand magazine being used and with no resistance such as we encounter with the smaller blow holes.

Since the volume of air and velocity is not present, there is no danger of the core box blowing apart. This type of blowing is being accomplished quite successfully, especially in semi-production and jobbing shops where only wooden core boxes are being used.

However, in the high production shop the size of the core sections, the contour of the core boxes and the density with which the core must be blown to make a quality core dictates the size of the blow holes and vent areas that must be used. Here, it is a well known fact that sands with greater flowability are moved much more readily than are sands with high green properties.

For instance, where sands that are used for shell core blowing are being moved with air, the sand flows more readily. Therefore, the volume of air required to fill a given core box cavity is considerably less than that required with sands of high green properties. As the green properties increase, it becomes more difficult to move sand through small blow holes. Eventually it becomes necessary to use agitators to break up the sand and get it in suspension with the air.

Agitators

Figure 3 is an illustration of at least two types of agitators that are being successfully used. This figure also points out two methods of quick changing blow plates. There are many others that are being used quite successfully, but the plates in this figure are used almost exclusively for open face core boxes. The quick change method in Fig. 4 is used almost exclusively for horizontally split core boxes.

Core boxes are attached to a ⅝-in. steel plate which is placed underneath the rails, sliding it in from either end. It is located in the center by mechanical means and sealed against the magazine plate by drawing up the bolts. The number used depends entirely on the length of the core. This is usually accomplished with a ratchet wrench. The plate with

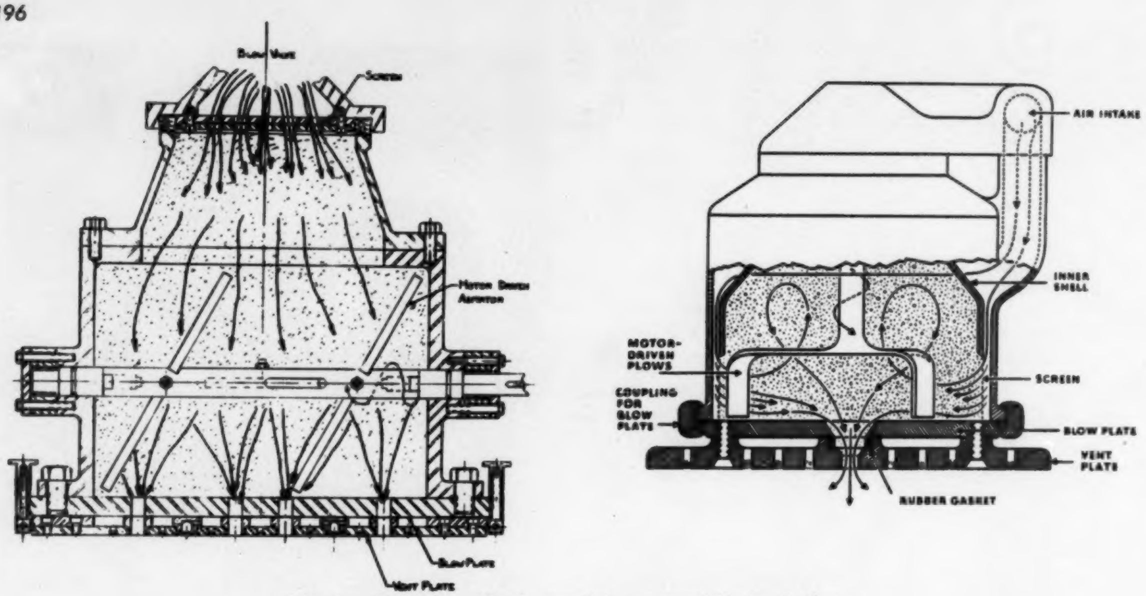


Fig. 3 — Two types of agitators being successfully used. Two methods of quick changing blow plates are also illustrated.

which the box is attached should overlap the opening in the magazine plate at least 1 in. for the best results. This method is used to make frequent changes with a minimum of lost time.

ACCURATE SAND CONTROL

Among the categories of important factors is, of course, sand control, and it can best be described by studying Fig. 5. The primary purpose of this illustration is to emphasize the uniformity that can be obtained in cores made on a blower, particularly in relation to sagging.

These cores, when assembled, form the main body of a six cylinder diesel block. They are 33 in. long, 13 in. wide, and vary in height from 3 to 8 in. There is $\frac{1}{8}$-in. finish on all main bearing facings, $\frac{1}{8}$-in. in the cylinder bore and $\frac{1}{8}$-in. on the head and pan face. After baking, the cores are not rubbed as is the usual practice, but are placed on an assembly gage and bolted together as a single unit.

Due to the small amount of finish allowed in a unit of this size there must be a complete absence of distortion. For example, if each of the 12 cores sagged $\frac{1}{64}$-in., the completed assembly unit would be $\frac{3}{16}$-in. narrow, with the result that the outside bore and main bearing would be $\frac{1}{16}$-in. under specified requirement. Actually the distortion in these cores is so slight that it hardly is measurable. This condition is directly attributed to close sand control.

The above, of course, cannot be accomplished with wet sand. For instance, once the clays and additives in the sand have been saturated with water maximum green properties with proper mulling can be obtained. When more water than is required for this purpose is added to the sand mix, the air

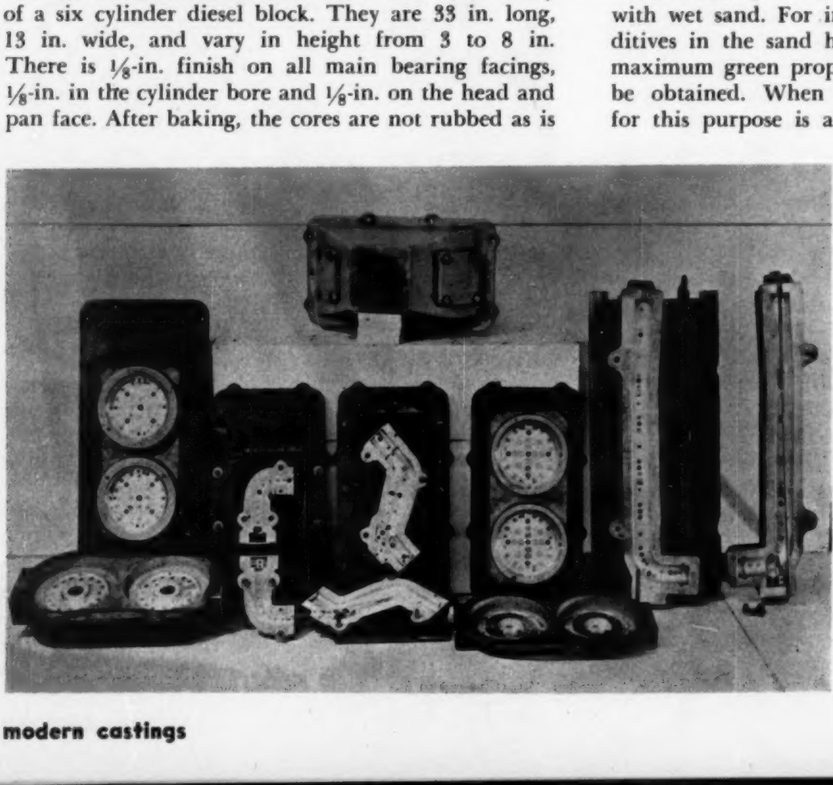


Fig. 4 — Another example of quick change blow plates. This method is used almost exclusively for horizontally split core boxes.

(when the blow valve is actuated) carries the free water to the surface of the core box and causes the sand to stick. This makes it impossible to obtain a smooth core finish or a smooth casting surface.

Dry sand will not hold specified core requirements and, therefore, is detrimental to the practice. When dry sand is used for the purpose of shell core making, for instance, this sand can readily be controlled with pressure regulators. Once the sand is cured, sagging is not a problem as is the case in a conventional sand practice.

CHOOSING THE CORRECT VENT AND BLOW HOLE AREAS

This brings up a question that is so often raised: Is their some method by which the vent area to blow hole area can be determined beforehand? Many attempts to accomplish this have been called to the writer's attention. But to his knowledge, as of this writing, there are no standards that can be used successfully. It is only natural, however, that in the course of time numerous core boxes are encountered with striking similarities. The rigging of such core boxes is then a simple matter because it can be duplicated from past experience.

There are so many cases, however, where the contour, size, shape of core boxes and sand physical properties change to the extent that the application of basic fundamentals and principles alone is not sufficient. Then the craftsman's imagination and ingenuity becomes an essential element enabling the core room supervisor to consistently get quality cores.

It is perhaps wise at this time to point out to the craftsman doing the rigging of core box and pattern equipment that there are a great number of methods used to prevent the wearing of core boxes directly underneath the blow holes. There are plastics, solders, hardened steel inserts, etc., and individual operators usually swear by one of the number of materials available. However, there is no hard and fast method that is universally accepted.

Vertical Position Blowing

All pin cores in Fig. 6 can be blown in a vertical position. Both vertical and horizontal clamps are used. The blow plate used does not have holes corresponding to individual cores. The length and width of the single elongated blow hole depends on the length of the box and the diameter of the core. As shown in Fig. 6, a variety of core boxes can be blown. All that is necessary is that the core box surface completely covers the hole in the blow plate. The number and diameter of cores are of no consequence.

The center examples are for the benefit of the craftsman also. These cores normally were cast in a horizontal position. They buckled and broke from the metal pressure. To overcome this problem stools were inserted in each half of the core box cradling a ¼-in. rod. Crescent shaped blow holes blow up the core, resulting in a core rigid enough to withstand the metal pressure, and no buckling or breaking of the core occurs.

The top view illustrates one method of blowing pin

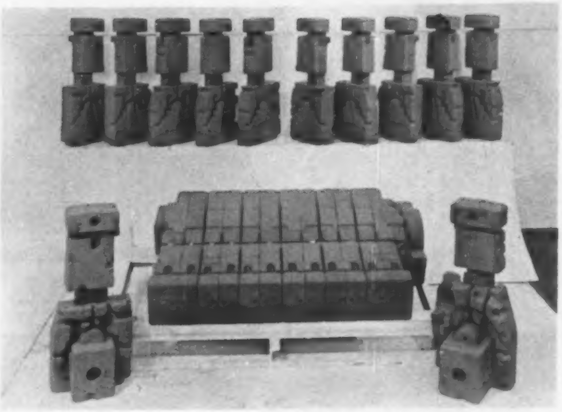


Fig. 5 — Uniformity of sand obtained in cores made on a blower, particularly in relation to sagging.

cores. Because reinforcement wires are required, one end of the core box is closed necessitating vents in the body of the core box itself to get rid of the air.

Figure 7 shows a group of core boxes that were blown with a complete absence of vents, but provisions were made for the air to escape both at the bottom of the core box and at the top of it. The core box in the extreme center, however, has a ring chill and a tube chill set in it. In this case the air has a tendency to accumulate underneath the chills making the vents necessary.

Horizontal Position Blowing

The method of blowing, as shown in Fig. 8, is somewhat similar to the method we used to blow pin cores. Pin cores are blown in a vertical position from one end, and these cores are blown in a horizontal position in both ends. The sand chambers on both ends of the boxes are hollow. However, in the one core box there are corresponding openings in the plate to which they are attached, while in the case of the larger core box (Fig. 8a) an elbow is used for the blow holes. Steel bushings are inserted in the blow holes with a break-off pad underneath. These pads are more easily distin-

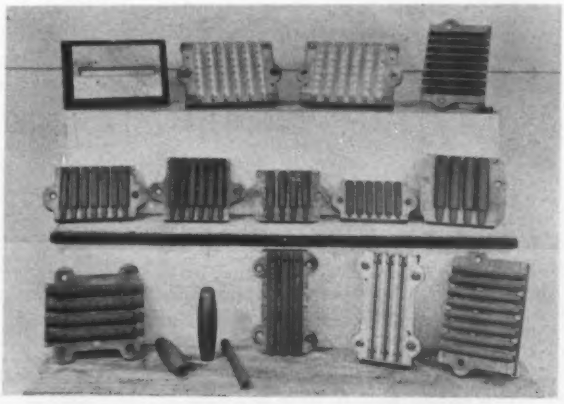


Fig. 6 — Pin cores which can be blown in a vertical position.

Fig. 7 — Core boxes which were blown without vents, although provisions were made for air to escape at the bottom and top of the core box.

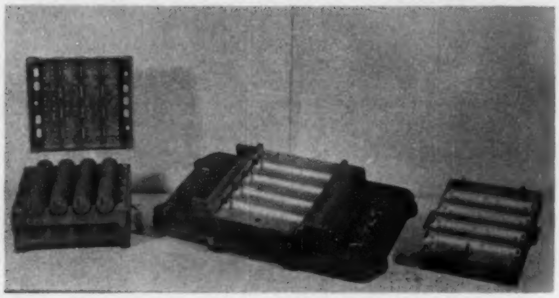


Fig. 8 — Cores blown in a horizontal position. The sand chambers on both ends of the boxes are hollow.

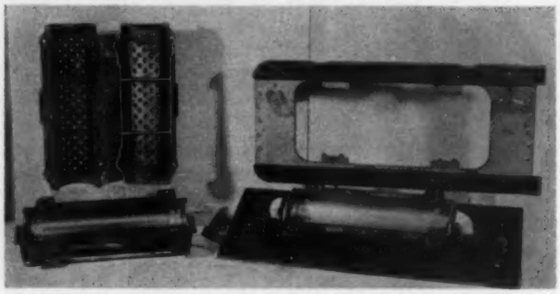
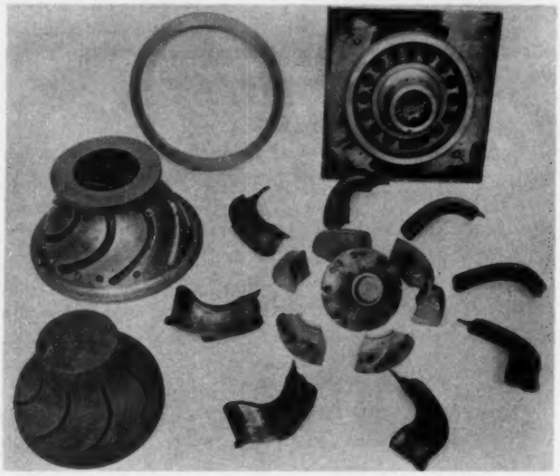


Fig. 8a — Larger core than shown in Fig. 8 with an elbow used for the blow holes.



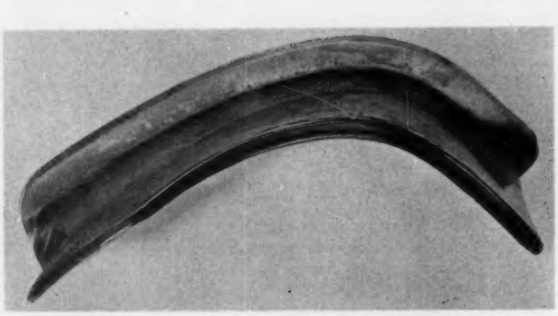


Fig. 9 — An 18 piece core box. Air pockets occurred at the curvature of the fins. It was determined that the sand was following the fin contour, but there was sufficient space between fin and center piece to allow air to escape beneath it. This caused an air pocket on the opposite side. The solution was to seal each fin, which eliminated the air pockets.

guished on the cores. The dryers, of course, are constructed to stack and interlock, thus conserving oven space.

Figure 9 is an illustration of an 18 piece core box. All possibilities of making a quality core appeared to be completely exhausted because air pockets persisted in occurring at the curvature of the fins. It was determined that the sand was following the contour of the fin, but there was sufficient space between the fin and the center piece to allow the air to escape underneath it. This caused an air pocket on the opposite side. The solution was to seal the individual fins, as shown in Fig. 9, which completely eliminated the air pockets that were occurring and perfect cores were the result.

Less venting is required for the more flowable sands because less air volume is required for blowing. Conversely, greater vent area is required when using sands of high green strength, due to the increased volume of air needed for blowing.

The air required to move a given volume of sand into the core box cavity eventually goes out into the atmosphere. The faster this air can escape, the greater the impact of the sand in the core box and the greater the density of the core.

The diameter of the blow holes and the vents used to accommodate the volume of air needed to move the sand, determines the density and the quality of the core or mold being blown.

ACKNOWLEDGMENT

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CANADIAN NON-FERROUS AND IRON FOUNDRY SAND PRACTICE SURVEY

Report of AFS Sand Div. Canadian Committee 8-Y

by A. E. Murton

ABSTRACT

A survey was conducted by the AFS Canadian Sand Committee (8-Y) of foundry sand practice. The results indicate that Canadian foundries gradually have been changing from natural to synthetic sand systems, mostly because they feel this will effect better control of their sand properties. Details of the complete survey, covering different types of foundries are given.

INTRODUCTION

Canadian Sand Committee 8-Y of the American Foundrymen's Society sent a questionnaire to 74 representative Canadian foundries to determine the type of program they would prefer the Committe to carry out. Only 20 replies were received from these.

Fifteen of these foundries indicated that they sometimes had sand problems. Visits by committee members to the other foundries indicated that most of them had sand problems too, but the standard of acceptable surface finish varied widely with the type of casting being made.

The responding foundries had some foundry literature available but three did not use it. In one of these three the personnel did not speak English. The five foundries from the Province of Quebec which responded would like to receive literature in French. Fourteen of the foundries, including one from Quebec, would like additional literature in English. However, only half of the 14 had more than one textbook, such as ANALYSIS OF CASTING DEFECTS (AFS) and one periodical. Of the two foundries which did not wish any additional literature, one had a well-stocked library, and the other had almost none.

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Canadian Committee (8-Y): A. E. Murton, *Chairman*, P. H. B. Hamilton, *Vice-Chairman*, A. J. Barnwell, *Secretary*, Charles Bateman, Vincent H. Furlong, Thomas Lyons, James McConachie and Kent Woonton.

The AFS Technical Committee had suggested that a survey of Canadian sand practice would be a suitable project for the Canadian Sand Committee. All but two of the foundries wished the Committee to undertake this project. Some foundries also wished to have a list of Canadian Sands, and their performance.

SCOPE OF SURVEY

In accordance with the desires of the responding foundries the Committee undertook the proposed survey of sand practice in Canadian iron and non-ferrous foundries.

The Committee obtained details of the operation of what was considered to be a representative group of iron and non-ferrous foundries, and collected samples of their sands for test at the Mines Branch Laboratories.

Steel foundries were not included in this survey, because they keep in contact with each other through their own organization, and are conversant with current practice. Canadian steel foundry practice is similar to that of United States steel foundries, and Canadian iron and non-ferrous foundrymen who are interested in this can obtain details from periodicals.

The group of foundries included in the survey can be divided according to the type of work into several classifications:

1) Small brass fittings—plated.
2) Small brass fittings—unplated.
3) Ornamental brass.
4) Heavy brass.
5) Aluminum.
6) Light to medium gray iron, white iron.
7) Heavy gray iron.

However, it is common for foundries to make castings of more than one type.

The sand practices of these foundries range from

the use of natural sand, with no facing, conditioners, additives or tests, to completely synthetic sand systems.

It was noted that three foundries modified their sand practice during the time of preparation of the report (Foundries 18, 27, 28, Appendix, Tables 1-6). No effort was made to discover these cases, and it is likely that some of the other foundries have also made changes.

BRONZE — NATURAL SAND

The foundries experiencing the fewest sand problems are those employing three or four molders, using common alloys, bench molding bronze and aluminum castings. Most of these foundries use no facing, sand additives or mulling. Typically the molder prepares his own sand or has it done under his supervision. The good grades of natural sand produce good castings and can be used without mechanization.

This group of foundries makes few sand tests. Some have testing equipment which they may use once a day, or when the staff can find time.

Those foundries floor molding with these sands have trouble with drops.

BRONZE — SEMI-SYNTHETIC AND SYNTHETIC

Bronze foundries making large castings, or castings to be polished or plated, usually find that a simple natural bonded system does not produce the quality of castings they require. They mull the sand, may add a little southern or western bentonite, and control the properties by testing for moisture, permeability and green compressive strength. Some of these foundries have converted to synthetic sand because of the better control obtainable. They may add new sand and bentonite to their facing mixtures, which are used on some of their more difficult molds, or they may add some new sand and bentonite to each batch.

Bronze foundries using synthetic sand systems, or which mull natural sand, usually test their sands regularly. They also report more sand problems, mostly from inclusions, than do those using simple natural bonded sand systems. This appears to be the result of the higher standards they require, higher production and more difficult castings and alloys.

IRON — NATURAL AND SEMI-SYNTHETIC

Iron foundries appear to be more conscious of sand problems than are non-ferrous foundries. Of the 15 iron foundries using natural sand only three do not mull at least the facing sand. Two of these are the only foundries using no bentonite as an auxiliary bond. All three foundries without mullers have weak sand and use a large number of gaggers. The more common practice with natural sand is to add new sand to the heap, and add bentonite either to the heap or to the facing to compensate for burn-out and dilution with core sand, These foundries would therefore be classed as semi-synthetic.

Iron foundries usually select natural sands with higher strengths than those used by bronze foundries, but there are some exceptions to this rule. Two foundries use Canadian natural sands. One of these also uses some U.S. sand.

All but one of the foundries with natural or semi-synthetic sand use pitch or seacoal, or both. They base the amount added on the appearance of the castings.

About half of this group of iron foundries make some sand tests. These might be made once or twice a day or once a week, but some foundries test every batch of facing. Most foundries making tests test for moisture, permeability and green compressive strength, but one tests for moisture only, and one for moisture and permeability. Even when foundries test their sand they seem to base their additions more on its behavior in molding and casting than on sand tests.

The most common troubles encountered by iron foundries using natural sand are sand inclusions, with some scabs, rattails and buckles.

IRON — SYNTHETIC

Practices followed by foundries using synthetic sand systems include:

1) No new sand except in cores; no facing; all sand mulled.
2) New sand facing on some jobs; all sand mulled.
3) Mulled mixture of black and new sand facing on all jobs; facing only may be mulled.

These foundries used bank, lake or washed and dried silica sand, or a mixture of two of these, one fine and one coarse.

Canadian sand was used by two foundries in their synthetic sand system. One of these uses (with fair results) a local bank sand which contains considerable magnetite, mica, etc. An imported lake sand is used for cores. The other foundry was using a washed and dried sand from Lake Winnipeg. The quality of this was equal to that produced in the Ottawa, Ill. district, but the producer has now ceased operations. All but one of the synthetic iron foundries questioned used seacoal.

Dry sand molds with a black wash may be used for large castings. This method is being replaced by air-set molding, and to a lesser extent by CO_2 molding. High pressure molding is being used in one soil pipeshop.

These foundries make more tests than those using natural sands. All test their sands—some of them occasionally only once or twice a day, or once a week. Most test for moisture, green compressive strength and permeability; but two test for moisture only. Three foundries, in addition to the usual three tests, test screen distribution occasionally; and two of them also test for combustible materials and pH.

Buckles and scabs are the most common difficulties reported by the iron foundries with synthetic sand systems. To eliminate these an all new sand facing is sometimes used on difficult jobs. Some foundries experience trouble with sand drying out, especially when it was hot.

CORE SANDS

Bronze and small iron foundries tend to use a blend of fine and coarse sand. Usually the fine sand is a bank sand, between 80 and 150 AFS fineness number, and the coarse sand is lake sand, or washed and dried silica sand of about 60 AFS fineness number. Some small foundries use local building sands. Occasionally some natural bonded sand may be used to give green strength to core mixtures.

Small bronze and iron foundries often use fairly large additions of core oil to compensate for inferior raw materials and poor baking control. They sometimes prefer mixtures with poor collapsibility to prevent the core sand from diluting the heap. Iron foundries often use black wash on their cores, but bronze foundries usually prefer mica wash.

Foundries which have a synthetic sand system use the same sand for molds and cores. They control the additions of binder and the baking of the cores more carefully than do smaller foundries. Air-setting cores may be used for large molds and cores. These are baked if the facilities are available.

Carbon dioxide cores are fairly widely used by small and large foundries. Shell cores are often used for production runs of small castings. This is in contrast to shell molding, which is used by only a few bronze and iron foundries.

Pipe fitting foundries use green sand cores, sodium silicate cores, shell cores or oil sand cores.

CANADIAN NATURAL SANDS

Many foundrymen expressed a wish to obtain a source of Canadian sand to obtain lower freight rates. Because of the geographical distribution of Canadian foundries several widely separated sources of sand would have to be found to enable all foundries to have a convenient source. The survey found only one source of Canadian natural bonded sand in use from Waterdown, Ontario, near Hamilton. This source is located close to many foundries in Ontario, but most of these import U.S. sands. There are probably other Canadian natural bonded sands having a limited use.

The results of a survey of Canadian natural bonded molding sands made by C. H. Freeman were published in 1936.* At that time it was estimated that 55-60 per cent of Canadian consumption was imported. The proportion must be around 90 per cent now. The book described tests on 72 working deposits, 31 formerly operated deposits and 45 prospects. It is evident that there has been a large decrease in the number of working deposits.

A study of the properties of the sands reported in Freeman's book shows that most of them were too low in permeability or green compressive strength to be suitable for anything but small work. Less than 25 per cent had a permeability between 10 and 100, together with a green compressive strength greater than 5 psi. In addition, many Canadian foundry sands with good moldability have a high lime content, or have clays with poor durability.

*"Natural Bonded Moulding Sands of Canada," Correll H. H. Freeman, Department of Mines and Technical Surveys, Ottawa, Ontario (1936).

CANADIAN BANK AND SILICA SANDS

A few foundries use Canadian bank or silica sands for core work. Some small bronze foundries use local building sand, and a few iron and non-ferrous foundries in the Montreal district and in Western Ontario use Canadian bank sands. Washed and dried silica sand, comparable to sand from the Ottawa, Ill. district, was being sold to foundries in Western Canada but this source has been discontinued. It is said that the barge charges on this sand from Black Island in Lake Winnipeg became too high for it to compete with U.S. sands.

Some Canadian sandstones, from a widely occurring formation known as the Potsdam sandstone, have been processed for molding sand for iron and steel. The most notable producer was Kingston Silica Mines Ltd. This company failed when it was unable to raise capital to open a new deposit. The old one, which had an obsolescent plant, had been worked out.

Potsdam sandstones in the Montreal district are being processed to make glass sands. Foundry sands are being sold from these, but the proportion used is small.

CONCLUSION

The results of this survey indicate that Canadian foundries have gradually been changing from natural to synthetic sand systems, mostly because they feel this will effect better control of their sand properties.

Shipments of off-grade natural sand (probably due to depletion of some of the good sand beds) have helped to make some foundrymen change to synthetic sand. The most common complaints have been sand containing clay balls and sand with too low strength.

Some bronze foundrymen and most iron foundrymen find that a simple natural bonded system will not give them the sand control they need. They add bentonite and mull the sand, and some feel they may as well go all the way to a synthetic sand system.

Foundries committed to the use of synthetic sand do not often revert to natural sand. If troubles are encountered they try to meet them by better moisture control, sand additives or more new sand. Even if these measures are only partially successful, they stick with synthetic sand because they have learned that there is no easy way out.

Although foundrymen wish to find sources of Canadian sand, they are using less of this sand than they were a few years ago. There are no widely used sources of Canadian natural or sharp sands. Some Canadian suppliers have gone out of business. Sands from some of the other sources are inferior to those from the U.S.A.

Producers who have failed to establish permanent operations have been troubled by small markets, high freight rates and difficult winter operations. Probably the time will come when Canadian sands of suitable grade can be produced economically. Canadian foundrymen have shown that under these conditions they will use Canadian sands.

APPENDIX

TABLE 1 — SAND PRACTICE — BRONZE AND ALUMINUM, NATURAL SAND

Foundry No.	Sand	Preparation	Rebond	Additives	Troubles Reported	Remarks
1	Natural	Aerate	New sand to heap regularly	None	None	Marine fittings; have second heap of finer sand for aluminum
2	Natural	Shovel	New sand to heap occasionally	None	None	Aluminum
3	Natural	Shovel	New sand to heap occasionally: facing of new and old sand on special jobs	Western bentonite to heap occasionally	Burn-in moisture control	Jobbing
4	Natural	Mix and aerate all sand	New sand to heap occasionally	None	"Usual"	Jobbing
5	Natural	Shovel	New sand to heap occasionally	None	None	Jobbing

TABLE 2 — SAND PRACTICE — BRONZE AND ALUMINUM, MULLED NATURAL AND SYNTHETIC SAND

Foundry No.	Sand	Preparation	Rebond	Additives	Troubles Reported	Remarks
6	Natural	Mull all sand; no facing	New sand to heap occasionally	None	Sand inclusions on polished goods	Plumbing fixtures
7a	Natural	Mull all sand; no facing	New sand to system regularly; bentonite to muller	Southern bentonite	Sand inclusions on polished goods, buckles, poor flowability	Brass foundry section; plumbing fixtures
8	Natural	Mulled old sand facing on all molds; aerate heap	New sand to heap regularly; bentonite to muller	Southern bentonite, western bentonite, wood flour	None	Jobbing
9	Natural	Mull all sand; no facing	New sand to heap; bentonite to muller	Southern bentonite	None	Plumbing fixtures; sand prepared once a week; plant at 15% capacity
10a	Natural	Mull all sand; new and old sand facing on some jobs	New sand to heap occassionaly; bentonite to muller	Southern bentonite, wood flour	None	Brass foundry section; valves and fittings; also small iron valves
11	Natural	Mulled old sand facing on all molds; cut heap	New sand to heap regularly; bentonite to muller	Western bentonite	None	Jobbing
12a	Natural	Mull all sand; no facing	New sand and additives to muller occasionally	Southern bentonite, cereal	Veining	Brass foundry division; jobbing up to 1½ tons; use dry sand on some jobs
13	Bank	Mull all sand; new and old sand facing on 25% of jobs	Bentonite and new sand to facing mixtures; bentonite to general purpose mixtures	Southern bentonite, wood flour, cereal	"Plenty, but better finish than with previous natural sand"	Plumbing, jobbing up to 1500 lb
14a	Bank sand for green sand; silica sand for dry sand	Mull all sand; new and old sand facing on all molds	New sand and additives to facing	Southern and western bentonite, wood flour to green sand; western bentonite, fireclay, cereal and pitch to dry sand	Sand inclusions	Jobbing; ship propellers, brass foundry section; use natural sand for small castings
15	Bank	Mull all sand; no facing	Additives to muller; new sand to system occasionally	Proprietary binder, wood flour	Inclusions on polished goods	Plumbing and heating goods, up to 10 lb

TABLE 3 — SAND PRACTICE — IRON, NATURAL AND SEMI-SYNTHETIC SAND

Foundry No.	Sand	Preparation	Rebond	Additives	Troubles Reported	Remarks
16	Natural	Shovel	New sand to heap occasionally	Seacoal	None	Jobbing, fittings
17	Natural	Shovel	New sand to heap occasionally	Seacoal	None	Jobbing, up to 2 tons
18	1) Natural 2) Blend of two natural sands	Mulled old sand facing on all molds; cut heap	New sand to heap regularly; bentonite to facing	Western bentonite, seacoal, gilsonite	(1) "usual" (scabs, blows) (2) None	Jobbing, up to 1000 lb. Sand changed from (1) to (2)
7b	Natural	New and old sand facing on all molds, some mulled, some aerated; aerate heap	Additions of new sand to heap and facing regularly; fireclay to mulled facing	Fire clay	None	Porcelain enamel, sanitary ware
19	Natural	Mulled new and old sand facing on all molds; aerate heap	All additions to facing	Western bentonite, seacoal, cereal	Burn-in	Gray iron, white iron mining equipment
20	Natural	Mull all sand; no facing	New sand to heap regularly; other additions to muller	Western bentonite, seacoal, wood flour	"general"	Light gray iron, valve bodies, floor molding
10b	Natural and washed silica	Mull all sand; new and old sand facing on all molds	All additions to facing	Western bentonite, seacoal	None	Iron foundry section, valves and fittings
21	Natural, washed and dried silica. and local bank	Mull all sand; new and old sand facing on all molds	All additions to facing	Seacoal, pitch	None	Jobbing, mostly gray iron
22	Natural	Mulled old sand facing on all molds; cut heap	All additions to heap	Western bentonite, seacoal	None	Pressure tight iron
23	Natural and lake	Mull all sand; new and old sand facing on all molds	All additions to facing	Southern and western bentonite, fireclay, seacoal, wood flour	None	Malleable
24	Natural and washed and dried silica	Mulled new and old sand facing on all molds; aerate heap	All additions to facing	Southern and western bentonite, proprietary binder, wood flour	Buckles on large copes	Large gray iron jobbing
25	Blend of two natural sands	Shovel and screen; no facing	All additions to heap	Western bentonite, fire clay, seacoal	Sand inclusions, drops, scabs	Gray iron jobbing
26	Natural	Mulled old sand facing on all molds; aerate heap	New sand to heap; other additions to facing	Fire clay, seacoal, pitch, cereal	Poor moisture control of heap sand	Gray iron jobbing; use some skin drying
27	Natural and lake	Mull and aerate all sand; no facing; green sand cores of lake and heap sand	All additions to muller	Western bentonite	First natural sand had clay grains which made permeability and strength sensitive to mulling. No troubles with second natural sand	Soil pipe fittings; high pressure molding
28 (old practice)	Two natural bonded sands, plus lake sand	Mulled new and old sand facing on all molds; cut heap	All additions to muller	Western bentonite, fire clay, seacoal, pitch, wood flour	Sand inclusions, penetration, scabbing	Heavy gray iron jobbing foundry; practice changed to synthetic, as described in Table 4
12b	Natural and washed and dried silica	Mull all sand; new and old sand facing on all molds	New sand to system and facing; other additions to facing	Western bentonite, fire clay, pitch compound, cereal	Scabs	Iron foundry section, heavy gray iron. Large molds baked
14b	Bank sand for green sand; dry sand uses same heap and practice as brass foundry dry sand	Mull all sand; new and old sand facing on all molds	All additions to facing	Southern bentonite, fire clay, cereal, seacoal to green sand facing	Sand inclusions, a few scabs	Iron foundry section

TABLE 4 — SAND PRACTICE — IRON, SYNTHETIC SAND

Foundry No.	Sand	Preparation	Rebond	Additives	Troubles Reported	Remarks
28 (new practice)	Bank	Mulled new and old sand facing on all molds; cut heap	All additions to facing	Southern and western bentonite, seacoal, cereal	Moisture control, scabbing, difficult shake-out	Improved over previous practice
29	50:50 coarse and fine bank sand	Mull all sand; no facing	All additives to muller; no new sand except in cores	Western bentonite, seacoal, pitch, wood flour	"General"	Light to medium gray iron jobbing
30	Bank and washed and dried silica	Mull all sand; no facing	All additives to muller; no new sand except in cores	Southern and western bentonite, seacoal	Erosion scabs	Light to medium gray iron jobbing
31	Bank	Mull all sand; no facing	New sand and additives to every batch	Western bentonite, fire clay, seacoal, wood flour	None	Light to medium gray iron jobbing
32	Bank	Mull all sand; all new sand facing on some molds	Most additions to facing; some bentonite to heap	Southern and western bentonite, seacoal	Buckles, rattails, erosion when no facing is used	Light malleable
33	Washed and dried silica	Mull all sand; no facing	All additives to muller; no new sand except in cores	Proprietary binder, seacoal	None	Small gray iron, nodular
34	Washed and dried silica	Mulled new and old sand facing on all molds; aerate heap	All additions to muller	Southern and western bentonite, proprietary binder, seacoal	None	Light to medium gray iron, bronze and aluminum
35	Bank and washed and dried silica	All sand mulled; no facing	All additives to muller; no new sand except in cores	Southern and western bentonite, proprietary binder, wood flour	None	Light to medium gray iron
36	Lake and local sand	All sand mulled and aerated; new and old sand facing on all molds	All additions to muller	Western bentonite, fire clay, seacoal	Hot sand, scabbing	Gray iron, nodular, up to 3 tons
37	Lake	Mulled new and old sand facing on all molds; aerate heap	All additions to muller	Western bentonite, seacoal, cereal	Periodic scabs	Gray and white iron mining equipment

TABLE 5 — TYPICAL MOLDING PROPERTIES, BRASS SANDS

Foundry No.	1	1	2	3	3	4	4
Sample	New	Heap	Heap	New	Heap	New	Heap
Type	Natural	Natural	Natural	Natural	Natural	Natural	Natural
Source of New Sand	New York	New York	New York	New York	New York	New York	New York
Condition	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	8.5	8.9	6.8	8.2	7.4	9.3	7.6
Permeability	9.0	13.0	15.7	7.2	8.4	8.2	10.3
Green Comp. Str., psi	8.4	7.7	7.2	5.7	5.2	8.2	6.3
Green Deformation, %	2.75	2.8	1.9	2.2	1.6	2.6	2.3
Green Tens. Str., oz/in.^{2}	3.5	3.6	5.0	3.6	3.3	4.3	2.2
Dry Comp. Str., psi	68	44	32	61	23	56	50
AFS Clay Content, %	—	—	10.0	14.8	—	—	—
AFS Fineness No.	—	—	173	208	—	—	—
Foundry No.	5	6	7a	7a	8	8	9
Sample	New	Heap	New	System	New	Heap	Heap
Type	Natural	Natural	Natural	Natural	Natural	Natural	Natural
Source of New Sand	New York	New Jersey	New York	New York	New York	New York	New York
Condition	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	—	4.8	10.7	6.8	9.4	7.3	6.8
Permeability	—	17.3	18.4	23.8	6.0	9.3	10.3
Green Comp. Str., psi	—	10.6	6.0	5.9	9.4	11.9	9.1
Green Deformation, %	—	1.5	2.1	2.15	2.95	2.5	2.45
Green Tens. Str., oz/in.^{2}	—	9.0	1.9	4.7	5.4	8.0	5.9
Dry Comp. Str., psi	—	48	41	79	74	171	71
AFS Clay Content, %	—	10.0	8.8	11.2	12.4	—	13.2
AFS Fineness No.	—	144	145	147	167	—	143

(continued on next page)

TABLE 5 — TYPICAL MOLDING PROPERTIES, BRASS SANDS *(continued)*

Foundry No.	10a	11	12a	13	13
Sample	System	Facing	System	System	New
Type	Natural	Natural	Natural	Synthetic	Bank
Source of New Sand	New Jersey	New York	New York	New York	New York
Condition	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	5.6	6.2	4.5	4.5	—
Permeability	17.3	7.7	13.4	25.5	—
Green Comp. Str., psi	13.1	10.0	10.4	10.0	—
Green Deformation, %	2.45	2.3	2.0	1.5	—
Green Tens. Str., oz/in.^{2}	12.6	7.6	11.8	17.0	—
Dry Comp. Str., psi	97	88	134	64	—
AFS Clay Content, %	13.1	15.8	10.7	—	1.0
AFS Fineness No.	138	203	163	—	161

Foundry No.	14a	14a	14a	14a	15	15
Sample	Heap	New	Green facing	Dry facing	New	System
Type	Natural	Bank	Synthetic (bank)	Synthetic (silica washed and dried)	Bank	Bank
Source of New Sand	New York	Mich.	Mich.	New Jersey	New York	New York
Condition	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	7.2	—	4.6	8.1	—	4.5
Permeability	36	—	38	38	—	22.7
Green Comp. Str., psi	6.7	—	11.2	11.8	—	15.8
Green Deformation, %	2.3	—	1.95	3.8	—	1.5
Green Tens. Str., oz/in.^{2}	8.2	—	17.6	13.4	—	22.4
Dry Comp. Str., psi	74	—	60	218	—	82
AFS Clay Content, %	10.8	0.5	6.0	6.8	0.5	9.9
AFS Fineness No.	144	122	99	88	139	93

TABLE 6 — TYPICAL MOLDING PROPERTIES — IRON SANDS

Foundry No.	16	16	16	17	17	17
Sample	New Bench	New floor	Heap	New	Heap	Heap
Type	Natural	Natural	Natural	Natural	Natural	Natural
Source of New Sand	New York	New York	New York	New Jersey	New Jersey	New Jersey
Condition	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.	Retempered
Moisture, %	8.5	7.0	7.5	8.5	9.2	8.0
Permeability	6.5	33	28	36	31	48
Green Comp. Str., psi	7.6	5.8	4.4	10.8	5.2	6.3
Green Deformation, %	2.6	2.4	2.5	3.55	3.4	2.7
Green Tens. Str., oz/in.^{2}	3.5	3.6	1.4	16.2	2.5	2.5
Dry Comp. Str., psi	60	77	25	74	89	72
AFS Clay Content, %	—	—	—	15.8	—	—
AFS Fineness No.	—	—	—	7.0	—	—
Seacoal (by heavy liquid)	—	—	—	—	—	—

Foundry No.	18	18	18	18
Sample	New (1958)	New (1958)	Heap (1958)	Heap (1959)
Type	Natural	Natural	Natural	Natural
Source of New Sand	New Jersey	New Jersey	New Jersey	New Jersey
Condition	As rec'd.	Mulled	As rec'd.	As rec'd.
Moisture, %	6.5	6.9	6.3	7.1
Permeability	80	67	58	73
Green Comp. Str., psi	10.6	13.8	9.7	3.2
Green Deformation, %	3.2	3.05	2.6	3.4
Green Tens. Str., oz/in.^{2}	18.6	29.0	14.8	3.0
Dry Comp. Str., psi	53	80	113	120
AFS Clay Content, %	15.6	15.6	—	5.5
AFS Fineness No.	65	65	—	60
Seacoal (by heavy liquid)	—	—	—	3.5

Foundry No.	7b	7b	7b	7b	7b	7b
Sample	Slinger facing	Slinger heap	Hand foundry heap	New	New	New
Type	Natural	Natural	Natural	Natural	Natural	Natural
Source of New Sand	New York	New York	New York	New York	New York	New York
Condition	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	5.6	5.9	5.9	7.8	8.5	5.1
Permeability	46	46	16.2	9.4	22.7	50
Green Comp. Str., psi	7.3	4.1	6.3	9.5	17.0	5.0
Green Deformation, %	2.4	2.25	2.3	2.8	3.4	1.55
Green Tens. Str., oz/in.^{2}	7.8	3.2	4.1	7.1	25.2	2.5
Dry Comp. Str., psi	71	55	79	144	131	27
AFS Clay Content, %	11.2	11.5	11.3	13.7	20.3	6.6
AFS Fineness No.	102	101	126	140	88	94
Seacoal (by heavy liquid)	—	—	—	—	—	—

(continued on next page)

TABLE 6 — TYPICAL MOLDING PROPERTIES — IRON SANDS *(continued)*

Foundry No.	19	19	20	20	10b
Sample	New	Heap	New	Heap	System
Type	Natural	Natural	Natural	Natural	Natural
Source of New Sand	New Jersey	New Jersey	New Jersey	New Jersey	Mixture of New Jersey and Ontario
Condition	Mulled	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	7.8	7.3	12.2	6.7	4.6
Permeability	16.7	52	9.0	16.2	54
Green Comp. Str., psi	15.6	15.2	5.5	9.9	13.4
Green Deformation, %	4.0	3.6	3.7	2.7	2.45
Green Tens. Str., oz/in.^{2}	27.4	23.4	3.7	8.6	16.0
Dry Comp. Str., psi	87	133	129	156	122
AFS Clay Content, %	19.4	—	14.6	—	7.9
AFS Fineness No.	102	—	133	—	79
Seacoal (by heavy liquid)	—	—	—	—	7.3

Foundry No.	21	21	22	22	23	23
Sample	Heap	Heap	Facing	Heap	Core	Heap
Type	Natural	Natural	Natural	Natural	Lake	Natural
Source of New Sand	New Jersey	New Jersey	New Jersey	New Jersey	Indiana	New Jersey
Condition	As rec'd.	Retempered	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	5.6	6.7	8.4	4.8	—	6.0
Permeability	80	52	9.4	17.3	—	52
Green Comp. Str., psi	10.6	10.1	9.4	10.6	—	15.0
Green Deformation, %	1.95	3.6	2.25	1.5	—	2.1
Green Tens. Str., oz/in.^{2}	7.6	11.0	9.6	9.0	—	18.0
Dry Comp. Str., psi	43	120	103	48	—	106
AFS Clay Content, %	12.0	—	16.5	12.6	0.0	—
AFS Fineness No.	75	—	95	93	53	—
Seacoal (by heavy liquid)	2.9	—	—	—	—	—

Foundry No.	24	25	26	26	26	26
Sample	Heap	Heap	Core	Core	Floor	Machine
Type	Natural	Natural	Lake	Washed and dried silica	Natural	Natural
Source of New Sand	Unknown	New Jersey	Indiana	New Jersey	Ontario	Ontario
Condition	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	5.1	10.2	—	—	6.7	7.6
Permeability	42	61	—	—	21.8	11.4
Green Comp. Str., psi	15.1	3.3	—	—	6.1	7.2
Green Deformation, %	2.95	3.45	—	—	2.2	2.2
Green Tens. Str., oz/in.^{2}	32.3	1.7	—	—	2.2	2.8
Dry Comp. Str., psi	164	81	—	—	75	69
AFS Clay Content, %	—	20.0	0.0	0.0	11.0	13.6
AFS Fineness No.	—	126	53	62	122	139
Seacoal (by heavy liquid)	—	—	—	—	—	—

Foundry No.	27	27	27
Sample	New (March)	System (March)	New (Sept.)
Type	Natural	Natural	Natural
Source of New Sand	Ohio	Ohio	Ohio
Condition	Mulled	As rec'd.	Mulled
Moisture, %	8.5	7.3	7.2
Permeability	13	49	44
Green Comp. Str., psi	17.2	6.8	17.5
Green Deformation, %	4.3	3.0	2.5
Green Tens. Str., oz/in.^{2}	18	5.4	34.8
Dry Comp. Str., psi	233	119	102
AFS Clay Content, %	28.2	—	18.4
AFS Fineness No.	97	—	67

(continued on next page)

TABLE 6 — TYPICAL MOLDING PROPERTIES — IRON SANDS *(continued)*

Foundry No.	**28**	**28**	**28**	**28**	**28**
Sample	Facing (1958)	Dry sand (1958)	New (1958)	New (1958)	New (1959)
Type	Natural	Natural	Natural	Natural	Bank
Source of New Sand	Ontario and New Jersey	Ontario and New Jersey	New Jersey	Ontario	Michigan
Condition	As rec'd.	As rec'd.	Mulled	Mulled	As rec'd.
Moisture, %	5.9	6.2	7.9	8.3	—
Permeability	90	55	119	50	—
Green Comp. Str., psi	10.1	12.2	18.4	14.9	—
Green Deformation, %	2.8	3.3	2.55	4.4	—
Green Tens. Str., oz/in.^{2}	10.2	14.5	34	24.6	—
Dry Comp. Str., psi	118	164	79	182	—
AFS Clay Content, %	—	8.1	19.6	21.9	1.5
AFS Fineness No.	—	48	32	80	55

Foundry No.	**12b**	**14b**	**14b**	**29**	**30**
Sample	Facing	New	Green facing	System	Heap
Type	Natural	Bank	Synthetic	Synthetic	Synthetic
Source of New Sand	New Jersey	Ontario	Ontario	Mich. and Penn. bank sands	Mich. bank, New Jersey washed and dried silica, Ohio natural
Condition	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	5.5	—	5.4	5.2	4.3
Permeability	80	—	63	61	75
Green Comp. Str., psi	7.4	—	13.0	12.5	11.9
Green Deformation, %	3.0	—	2.25	2.35	2.6
Green Tens. Str., oz/in.^{2}	11.8	—	16.8	19.2	18.2
Dry Comp. Str., psi	75	—	143	91	155
AFS Clay Content, %	9.0	0.8	—	—	—
AFS Fineness No.	51	85	—	—	—

Foundry No.	**31**	**31**	**32**	**32**	**33**
Sample	New	System	New	Heap	Heap
Type	Bank	Synthetic	Bank	Synthetic	Synthetic
Source of New Sand	Michigan	Michigan	New York	New York	Minnesota
Condition	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	—	7.9	—	4.3	5.8
Permeability	—	16.2	—	54	38
Green Comp. Str., psi	—	14.6	—	7.8	17.8
Green Deformation, %	—	—	—	2.05	2.25
Green Tens. Str., oz/in.^{2}	—	15.8	—	12.2	35.0
Dry Comp. Str., psi	—	244	—	122	—
AFS Clay Content, %	0.0	—	0.1	—	—
AFS Fineness No.	53	—	108	—	—

Foundry No.	**34**	**35**	**35**	**36**	**36**
Sample	Facing	New	Heap	New	System
Type	Washed and dried silica	Bank	Synthetic	Bank	Synthetic
Source of New Sand	Manitoba	Michigan	Michigan	Local (Ontario)	Ontario and Indiana
Condition	As rec'd.	As rec'd.	As rec'd.	As rec'd.	As rec'd.
Moisture, %	6.9	—	5.7	—	5.5
Permeability	38	—	42	—	61
Green Comp. Str., psi	13.4	—	16.4	—	9.8
Green Deformation, %	1.55	—	2.1	—	2.8
Green Tens. Str., oz/in.^{2}	28.4	—	25.0	—	18.4
Dry Comp. Str., psi	222	—	82	—	174
AFS Clay Content, %	—	0.3	—	1.8	—
AFS Fineness No.	—	110	—	132	—

(continued on next page)

TABLE 6 — TYPICAL MOLDING PROPERTIES — IRON SANDS *(continued)*

Foundry No.	37	37	37
Sample	New	Facing	Heap
Type	Lake	Synthetic	Synthetic
Source of New Sand	Indiana	Indiana	Indiana
Condition	As rec'd.	As rec'd.	As rec'd.
Moisture, %	—	4.5	4.1
Permeability	—	126	126
Green Comp. Str., psi	—	13.2	12.2
Green Deformation, %	—	3.25	2.45
Green Tens. Str., oz/in.^{2}	—	25.5	22.6
Dry Comp. Str., psi	—	105	108
AFS Clay Content, %	0.0	—	—
AFS Fineness No.	51	—	—

TABLE 7 — SAND TESTING PRACTICE OF CANADIAN FOUNDRIES

Foundry No.	Metal	Sand	Tests: Mois.	Tests: Perm.	Tests: Gr. Comp. Str.	Tests: Other
1	Bronze	Natural	Daily	—	—	—
2	Aluminum	Natural	—	—	—	—
3	Bronze	Natural	Occasionally	Occasionally	Occasionally	—
4	Bronze	Natural	—	—	—	—
5	Bronze	Natural	—	—	—	—
6	Bronze	Natural	Occasionally	Occasionally	Occasionally	—
7	Bronze and iron	Mulled Natural	Hourly	Hourly	Hourly	—
8	Bronze	Mulled Natural	4/day	4/day	4/day	—
9	Bronze	Mulled Natural	Weekly	Weekly	Weekly	—
10	Bronze and iron	Mulled Natural	Hourly	Hourly	Hourly	—
11	Bronze	Mulled Natural	—	—	—	—
12	Bronze and iron	Mulled Natural	4/day	4/day	4/day	Deformation 4/day ventability and bondability 2/day silt, clay, fines, volatile, carbonaceous, pH 2/week; hot properties occasionally.
13	Bronze	Synthetic	4/day	4/day	4/day	Deformation, 4/day
14	Bronze and iron	Natural and Synthetic	Every batch	2/day	2/day	—
15	Bronze	Synthetic	Hourly	Hourly	Hourly	Dry strength, combustible daily
16	Iron	Natural	—	—	—	—
17	Iron	Natural	Daily	—	—	—
18	Iron	Mulled Natural	—	—	—	—
19	Iron	Mulled Natural	—	—	—	—
20	Iron	Mulled Natural	Occasionally	Occasionally	Occasionally	—
21	Iron	Mulled Natural	4/day	4/day	4/day	—
22	Iron	Mulled Natural	—	—	—	—
23	Malleable	Mulled Natural	4/day	4/day	4/day	Screen test monthly
24	Iron	Mulled Natural	6/day	6/day	6/day	—
25	Iron	Unmulled Natural	—	—	—	—
26	Iron	Mulled Natural	—	—	—	—
27	Iron	Mulled Natural	2/hr	2/hr	—	—
28	Iron	Synthetic	6/day	6/day	6/day	Combustible, screen test monthly
29	Iron	Synthetic	Daily	Daily	Daily	—
30	Iron	Synthetic	Daily	Daily	Daily	Green deformation daily
31	Iron	Synthetic	2/day	2/day	2/day	Flowability, 2/day
32	Malleable	Synthetic	Daily	Daily	Daily	—
33	Iron	Synthetic	4/day	4/day	4/day	—
34	Iron and Nonferrous	Synthetic	Occasionally	—	—	—
35	Iron	Synthetic	Occasionally	—	—	—
36	Iron	Synthetic	3/day	3/day	3/day	Screen test occasionally
37	Iron	Synthetic	4/day	4/day	4/day	Screen test, combustible, pH occasionally.

Division Working on Three Books

■ Work on three AFS books is currently being conducted by various committees of the Sand Division. Reports on committee activities were made at the January meeting of the division's executive committee.

Books in progress:

MOLDING METHODS AND MATERIALS—36 papers, comprising six chapters have been completed; 95 papers covering 26 chapters will be reviewed in the near future.

CONTROLLED CASTINGS HANDBOOK—A quantity of pictures has been received through solicitation of the AFS chapters. Work is progressing on the manuscript.

SAND HANDBOOK—Several committees have completed their review of the book; others are expected soon so that final preparation can be made on the new edition.

Other reports:

Core test Committee—Working on tentative tests for CO_2 and air-setting binders. At next meeting to decide on future work on new materials.

Mold Surface Committee—Investigating all means for evaluating surface finish, the effect of mold surface and cleaning methods on the as-cast surface.

Shell Mold & Core Committee—Plans on developing a form to be used in reporting shell molding problems and their solutions. A sub-committee is considering the preparation on safeguards in handling shell mold materials. Consideration is being given to investigating improved shell cores for non-ferrous foundries, particularly for the casting of aluminum where a high degree of collapsibility is important.

Materials Used in Malleable Foundries Committee—A questionnaire is being prepared to be sent to all malleable foundries for use with the study of pinhole porosity defects in malleable castings.

Core Test Committee—Tentative tests on CO_2 and air-setting binders have been completed and a report will be carried in coming MODERN CASTINGS.

Canadian Committee—Committee report covering Canadian sands will be presented at the Castings Congress. P. H. B. Hamilton, Dominion Engineering Works, Ltd., Montreal, Canada, has been named as committee chairman succeeding A. E. Murton, resigned.

T. E. Barlow, Eastern Clay Products Dept., International Minerals & Chemical Corp., Skokie, Ill., was selected as the American corresponding representative to the International Working Group on Bonding Clays.

Board Names 2

■ National Director and former AFS President, L. H. Durdin, Dixie Bronze Co., Birmingham, Ala., has been re-elected by the AFS Board of Directors as an AFS-T&RI Trustee. He will serve a four-year term, 1960-1964.

National Director N. N. Amrhein, Federal Malleable Co., West Allis, Wis., has been elected by the AFS Board of Directors to a two-year term as an AFS Trustee to the Foundry Educational Foundation. He succeeds W. D. Dunn.

L. H. Durdin

N. N. Amrhein

Apprentice Contest Closes on April 8

■ April 8 is the closing date for national judging in the AFS Robert E. Kennedy Memorial Apprentice Contest. All entries must be received at the University of Illinois, Navy Pier, Chicago, not later than 5:00 pm.

Name T. T. Lloyd

■ Thomas T. Lloyd, associated with Albion Malleable Iron Co., Albion, Mich., since 1936 and with the recent acquisition of Muncie Malleable Foundry Co., Muncie Ind., vice-president in charge of operations at both locations, has been named an AFS Director at Large. Lloyd is chairman of the AFS Publications Committee and a member of the AFS-T&RI Course Advisory Committee.

T. T. Lloyd

AFS 1896

news and views

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E. M. Sobota P. C. Rosenthal V. A. Guebard, Jr. H. O. Boehm B. H. Booth P. Ritzenthaler R. L. Olson T. W. Curry

Wisconsin Regional Draws 600 to Foundry Conference

■ Disrupted transportation schedules and blocked highways caused by the area's worst snow storm of the winter failed to keep 600 foundrymen from the annual Wisconsin Regional Foundry Conference and the 25th anniversary of the Wisconsin Chapter.

Some speakers were delayed causing shuffling of the program, but the two-day conference, Feb. 11-12 at Milwaukee, was presented with only minor adjustments. Twenty technical talks in five major divisions were presented in simultaneous sessions. In addition there were talks of general interest, luncheons, a banquet, plant visitations and a ladies program.

Conference sponsors were the AFS Wisconsin Chapter and the University of Wisconsin. Lawrence J. Andres, Lawran Foundry Co., was conference president. Bradley H. Booth, Carpenter Bros., Inc., was conference general chairman with the following co-chairmen: Prof. P. C. Rosenthal, University of Wisconsin; E. M. Sobota, Wisconsin Electric Power Co.; V. A. Guebard, Jr., International Harvester Co.

Pattern Talks

Emphasis on new products and processes was stressed at the pattern sessions. Patternmakers were encouraged by William Weaver, Modern Pattern & Plastics Co. to diversify their operations and to consider adopting room temperature and high temperature epoxies, in his talk, *New Applications in Plastic Patternmaking*. Weaver stated that 60-70 per cent of the new business in his shop came through the new epoxies. O. J. Seeds, Cerro-De-Pasco Sales Corp., pointed out the advantages of ultra low melting metals having dimensional accuracy, speed of production and excellent reproduction in *The Hows and Whys of Low Melt Metals for Pattern Use*.

The increasing use of electrical deposition of metals, with the normal plating amounting to only a few thousandths of an inch but with superior bonding properties, was outlined by Phil Ritzenthaler, Plating Engineering Co., in presenting *Electroforming for Pattern Construction and Repair*. Advantages of making patterns by the Shaw process was described by Richard Christenson, Cast Masters. In most cases they are doing supplementary machining to get the final few thousandths of an inch accuracy required.

Gray Iron Talks

Strict maintenance of control and research was stressed in gray iron papers.

Six specific types of heat treatment at Lynchburg Foundry Co., were explained by P. H. Dirom, Jr., in *Heat Treatment of Gray Iron and Ductile Iron*. These types are: stress relieving, higher temperature stress relieving, low temperature annealing, high temperature annealing, normalizing and quenching in oil and tempering. T. W. Curry, also of Lynchburg Foundry, outlined and described various types of quality control, methods for installation and specific recommendations in *Quality Control in the Manufacturing of Gray Iron and Ductile Iron Castings*. By speeding the tests and their interpretation, you can narrow the spread of operating variables.

Victor Rowell, Federal Foundry Supply Div., Archer-Daniels-Midland Co., warned foundrymen that customers are placing increasing emphasis on quality whether the item is cast or fabricated by other means. In *High Strength Molding Sands for the Jobbing Shop*, he recommended investigation of the better mold wall stability and high temperature stability possible with these sands. Carl L. Loper, Jr., University of Wisconsin, in *The Gas-Fired Cupola*, reported on investigations at the university. The process holds many advantages as a replacement for coke in the foundry cupola. However, commercial use is not in the immediate future due to present limitations.

Non-Ferrous Talks

Defining and solving of various problems were discussed by non-ferrous speakers. *Problems of Aluminum Permanent Molding* were presented by a panel composed of Merlin Rostad, Rostad Aluminum; Edward Troy, Est Co.; William Eckert, Metamold Corp. Among the topics were the use of mold coatings, correct feeding and control of mold temperature.

Michael Bock, Exomet, Inc., in *Aluminum Risering, Feeding, Degassing and Grain Refinement*, pointed out that grain refining, degassing and risering for improved solidification and physical properties were all interrelated. The solution of one is only a partial solution of the problem. He forecast an increasing use of aluminum through new molding materials which will impart increased chilling effects on aluminum.

Practical applications in specific foundries were presented by W. R. Oakley, Delhi Foundry Sand Co. A set of slides illustrated the new CO_2 molding line for brass plumbing fittings at the foundry of American Standard Co. For proper sodium silicate additions, sand fineness should be measured frequently. Turbulence was advanced as the most common cause for scrapping non-ferrous castings by R. A. Colton, Federated Metals Div., American Smelting & Refining Co. Recommendations for minimizing turbulence were use of rectangular down sprues, use of a well under the down sprue, use of choke cores, placing of the sprue near the side of the flask and avoiding pouring from too great a height.

Malleable Talks

The importance of controls in all phases of foundry operations were stressed by malleable speakers.

Full benefits of work measurement

N. J. Dunbeck L. J. Andres

F. Less F. Fazzari

J. A. Schumann R. Wills D. E. Feather

standards cannot be obtained by management which looks upon them as necessary evils. Properly used, they can be the most valuable tools a manager can employ to keep his business healthy and profitable, said Robert Wills, Stevenson, Jordon & Harrison, in his talk on *Introduction and Administration of Standards*. He emphasized that the standards orientation meeting prior to the adoption of the standards is the most important step as far as workers are concerned.

A detailed description of *Air Furnace Operation* at Auto Specialties was given by Andrew Kavosi, Jr., Auto Specialties Mfg. Co. of Canada. A definite maintenance program is employed and attempts are made to keep all variables to a minimum. In varying tonnages, the only change is in the raising and lowering of the bottom—the height of the bridgewall is not changed; sidewalls and tapblocks are 28 in. above the bottom at all times and slope to 20 in. at the bridgewall; regardless of the tonnage melted, the burner remains at an angle of 15 deg horizontal and 5 deg on the vertical.

Watching moisture during the cycle of the sand is an important factor in the control of casting quality, J. S. Schumacher, Hill & Griffith Co., told foundrymen in *Sand Control and Casting Quality*. Schumacher reported on controlled moisture tests under normal foundry operating conditions where the optimum moisture content was 3.7 per cent. Variations up to 4.0 per cent and down to 2.7 per cent, all well within actual foundry limits, greatly affected the quality of the castings.

Advantages of using shell core sand were outlined by Frank Less, Durez Plastics, in *Shell Core Sand*. Included are: reduced weight on cores, elimination of driers, rods and wires, better storage characteristics and fewer ovens required.

Steel Talks

Steel speakers emphasized new developments in the foundry field. In *Alloy Control in Acid Steel Melting*, Harold Barnum, Vanadium Corp. of America, pointed out that alloys now comprise 25 per cent of all steel castings. He explained normal procedures in the acid steel melting down period and the reasons for the addition of iron ore and lime as well as the additions of slag deoxidizers and its effect on control of FeO and the effects of over-deoxidation.

R. A. Flinn, University of Michigan, in *Applications of Ceramics to Problems in Cast Metals*, pointed out the similarities in metal and ceramic phase diagrams. A study and knowledge of ceramics and their effect upon metals will likely solve many of the present foundry problems and lead to quality castings. Problems of ceramics in steel foundries are now encountered in the melting furnace, ladles, mold materials and the cleaning room.

A foundryman's view on a new polymer sand binder was given by Carl Baumgartner, Crucible Steel Castings Co. This extremely high molecular weight, synthetic, water soluble polymer has an extremely tenacious bond film character. Although the cost is high it is justified by: increased mold productivity (10 per cent more molds with the same manpower and molding hours); reduced handling costs; easier transport through pneumatic equipment; and the waxy residue left on pattern equipment allows a clean draw.

Natural Gas Cutting was discussed by a four-man panel. Chairman Don Koch, Sivyer Steel Castings Co., read the paper of author Glen Hibbard, Milwaukee Gas Light Co., who stated that some cutting jobs cannot be done as fast with natural gas as with oxy-acetylene but that most jobs can be done equally fast at less cost. He stated that all of the major steel supply companies in Milwaukee use natural gas to cut mill stock to order for their customers. Robert L. Lacy, Victor Equipment Co., told of the latest cutting equipment and of the advantages of the process which include low fuel cost and unusually clean cuts.

Raymond O. Fish, Harnischfeger Corp., emphasized that adequate volume must be present for satisfactory results since natural gas has a slower rate of combustion than does acetylene. This, combined with a somewhat lower developed flame temperature, makes it imperative that gas supply techniques be changed with a conversion to natural gas. Robert L. Laughrin, Falk Corp., described why his company did not adopt this method after a trial period. He added that whether or not the use of natural gas will save money depends upon the individual cost picture and gas cutting requirements.

General Talks

Kurt F. Wendt, Dean, College of Engineering, University of Wisconsin, and AFS Vice-President N. J. Dunbeck spoke at the Thursday morning kickoff. Dean Wendt outlined problems educators will be facing with the rising population. Many educators and industries will be faced with such problems as better training of personnel, greater increase on technical and vocational programs, and research.

Wendt stated that two factors are responsible for challenges that educators must face in the coming years. These are the increasing population and the increase in knowledge. Wendt said that 75 per cent of products now in use have been developed and manufactured on processes less than 15 years old.

Among problems facing educators are: an upgrading of the faculty, an expansion of technical programs, increased use of visual aids and a possible fifth year of college.

Dunbeck emphasized that industry must devote more of its funds to research and called attention to the small amount spent by the foundry industry for this purpose. He pointed out that much technical information is available through the AFS Training & Research Institute training program and the 64th Castings Congress.

Other speakers during the conference were John Varga, Battelle Memorial Institute, who spoke on *Recent Developments in the European Foundry Industry;* luncheon speakers Dr. Paul J. Mundie and the Rev. T. Parry Jones and banquet speaker Harold J. Ruttenberg.

■ Photos by Bob DeBroux

28th Southeastern Regional Foundry Conference

WELCOME . . . to the oldest consecutive foundry conference in the AFS . . . the 28th Southeastern Regional . . . sponsored by the Birmingham District Chapter, Tennessee Chapter and University of Alabama Student Chapter . . . held in Birmingham, Ala., Feb. 18 and 19.

And so 350 foundrymen and 75 ladies came to join in the technical conferences and social hospitality that typifies this annual meeting. Conference Chairman J. R. Cardwell, Stockham Valves & Fittings, Inc. and Vice-Chairman Ernest Finch, American Cast Iron Pipe Co., arranged a program that included ten technical speakers, a luncheon, banquet and ladies' reception. Traditionally, Friday morning was plant visit time and practically every Birmingham foundry and pattern shop opened its doors to visitors. Conference was climaxed with the annual banquet where Dr. V. Dewey Annakin, Indiana State College, provoked considerable thought with his talk on "Backdrop for Survival."

COMPARISON OF MOLDING METHODS . . . by **G. H. Sanders,** American Colloid Co., Skokie, Ill. . . . "There are many methods and practices to select from in operating a foundry. The foundry industry for years has been trying to improve on old methods, techniques of molding practice and the raw materials used. This is a healthy condition as it produces and encourages many advancements for such a basic industry." These were speaker Sander's opening remarks. He then described 13 different types of molds used for sand castings, 6 classifications for molding techniques and 5 special techniques.

HOW AFS IS MOVING AND WHY . . . by **A. B. Sinnett,** American Foundrymen's Society, Des Plaines, Ill. . . . This talk alerted foundrymen to the vast array of services available to them from AFS . . . including technical committee activities, Training & Research Institute courses and studies, MODERN CASTINGS magazine, Safety, Hygiene & Air Pollution Control, local Chapter meetings, annual Castings Congress and the biannual Exposition.

CHARGING MATERIAL FOR CUPOLA . . . by **R. A. Clark,** Union Carbide Metals Co., Div. of Union Carbide Corp., Cleveland . . . "The foundry cupola is a counterflow furnace in which the charge descending in the shaft is in close contact with fuel, fluxes and products of combustion. This is fortunate because it gives the cupola the highest thermal efficiency of any melting furnace. On the other hand, it introduces some problems in that the close contact between the metal and products of combustion causes reactions which are sometimes a little difficult to control." These are the words of speaker Clark who went on to describe in considerable detail the characteristics of different charge materials such as pig iron, scrap and alloys and how they affected the final analysis of the iron at the spout.

DUCTILE IRON-PRODUCTION AND CONTROL . . . by **H. Henderson,** Lynchburg Foundry Co., Lynchburg, Va. . . . "Ductile iron castings have replaced castings made of alloy gray iron, malleable iron, pearlitic malleable, plain carbon steel, alloy steel and bronze as well as steel weld-

T. T. Bales, chairman student AFS chapter, University of Alabama, J. R. Cardwell, conference chairman, and C. E. Seman, conference co-chairman.

R. A. Clark receives a set of AFS cuff-links from M. D. Neptune. Each speaker on the program received this award.

C. A. Sanders presents the opening talk at the conference.

Harvey Henderson addressed the conference on the subject of ductile iron.

A. B. Sinnett told about the future of AFS at session with L. H. Durdin presiding.

K. L. Landgrebe was chairman of the session at which C. E. Drury spoke about pouring variables.

ments and forgings of carbon steel, alloy steel and aluminum. An increasing number of parts are being designed in ductile iron and the drawings specify ductile iron of specific properties." Speaker Henderson followed these opening remarks with a step-by-step description of how Lynchburg produces ductile iron in a water-cooled protruding tuyere 1000 F hot-blast acid-lined cupola. He then traced all the controls exercised in melting, gating, risering, molding, pouring and inspection.

POURING EFFECT ON SCRAP . . . by **C. E. Drury,** Central Foundry Div., GMC, Saginaw, Mich. . . . "Although pouring rates will be affected by molding sand conditions, iron temperatures, analysis, design, gating, molding equipment, etc., this 1200-hr study dealt only with iron pressure and the area through which the iron flows," said Drury. He then proceeded to show how the pouring rate was influenced by sprue cups, sprue post diameter and length, runner area, runner chokes and ladle height.

FOUNDRY REFRACTORIES–1960 . . . by **J. H. Rickey, Jr.,** The Ironton Fire Brick Co., Ironton, Ohio . . . "Cupolas operating with acid slags use acid type refractories such as fire clay, brick, fire clay plastics, siliceous gun mixes and ramming materials . . . Only when a complete reline is needed does the foundryman revert to a full cupola block lining. Instead a monolithic patch is applied each day in the melting zone with an air placement gun or by hand ramming . . . Graphite bearing plastic refractories have melting points so high they are not melted by molten iron." The speaker then went on to describe ladle-lining practices and refractory requirements in malleable iron, steel and non-ferrous foundries.

NEW OPPORTUNITIES FOR THE PATTERN INDUSTRY . . . by **M. K. Young,** United States Gypsum Co., Chicago . . . Speaker Young pointed out that: "Because of negative thinking and resistance to change, only 10 to 15 per cent of the 13,000 patternmakers know how to use plastics and make plastic patterns . . . Plastic pattern fabrication is making possible new products that might have formerly died on the drawing boards or in the design stage because the customer did not have enough money to make new equipment by the traditional techniques." A film was shown to demonstrate techniques for making duplicate patterns and matchplates.

LET'S TAKE A LOOK AT SHELL MOLDING . . . by **O. Schopp,** Link Belt Co., Indianapolis . . . The speaker described evolution of the four-stage shell molding machine from the eight-stage machine. A color movie showed shell-molding operations at the Ewart Foundry. And a selection of small castings and shell cores demonstrated the capabilities of their resin-bonded sand system.

THE AIR WE BREATHE–IS IT FREE? . . . by **J. B. Skinner,** American Mutual Liability Insurance Co., Wakefield, Mass. . . . "You breathe 35 lb of air a day . . . you can live without food and water for days but only four minutes without air . . . the higher the metal-pouring temperatures and the bigger the castings the greater the hazard of silicosis in sand-system foundries . . . high temperatures convert quartz silica to the cristobalite form which is physiologically more damaging."

ENGINEERING CHARACTERISTICS OF STEEL CASTINGS . . . by **C. B. Jenni,** General Steel Castings Corp., Eddystone, Pa. . . . During the course of his talk, speaker Jenni pointed out that: "Steel castings can be produced in complex shapes with efficient distribution of metal, uniform structure, nondirectional properties, wide range of mechanical properties, good machinability and weldability, dimensional stability, fatigue resistance and creep resistance." Further remarks covered metallurgical control, foundry practices, nondestructive testing and inspection.

Ralph Carlson presided when J. H. Rickey, Jr. talked about modern foundry refractories.

C. E. Seman introduced speaker J. B. Skinner who explained some of the air pollution problems facing the foundry industry.

Ray Olson inspects the exhibit prepared by M. K. Young to illustrate his talk on new pattern techniques.

John Carpenter chairmanned the steel castings session which featured C. B. Jenni on the rostrum.

Speaker C. O. Schopp talks to session chairman Dan Dimick about shell molding.

Conference was closed with the traditional annual banquet.

ANNOUNCING . . . .

1960 TRAINING COURSES SPONSORED BY AFS TRAINING & RESEARCH INSTITUTE

APRIL—JULY

Subject and Description	*Dates*	*Course Length (Days)*	*Where Given*	*Course Fee*
Shell Molds and Cores A critical study of the process—its application, problems, and practical solutions for cost reduction. Methods of production and planning, mixes, mulling cycles, resins, sand and operating problems are intensively studied. Instructive information on shell cores—application, economics, procedures, casting quality and limitations. Course provides practical instruction for all interested foundry personnel. Typical case problems welcomed for class discussion. **COURSE NO. 6**	April 11-13	3	Chicago	$60
Production of Ductile Iron Melting equipment and melting practices are emphasized for lowering production costs. All phases of production are presented—metallurgy, inoculants, quality control, pouring practices, raw materials and inspection methods. Specialized course for all foundry personnel producing ductile iron or contemplating entering this casting field. **COURSE NO. 7**	June 27-29	3	Chicago	$60
Blue Print Reading, Estimating Basic fundamentals and principles necessary when considering new jobs. Job analysis techniques are presented in logical step-by-step procedure . . . including the initial reading of blueprints to production planning. Practical methods of estimating new jobs are studied, emphasizing "danger points" which can increase production costs. This course covers information which is vitally important for economically successful foundry operations. Key personnel involved in these responsibilities can learn new techniques. **COURSE NO. 8**	July 11-13	3	Chicago	$60

Courses to be Presented in AFS-T&RI 1960 Training Program

Welding and Brazing of Castings **$60**
Course No. 9 — Aug. 17-19 — Chicago

Core Practices **$90**
Course No. 10 — Aug. 29-Sept. 2 — Chicago

Foundry Refractories **$60**
Course No. 11 — Sept. 12-14 — Chicago

Economical Purchasing of Foundry Materials **$60**
Course No. 12 — Sept. 26-28 — Chicago

Sand Testing **$150**
Course No. 13 — Oct. 10-14 — Detroit

Foundry Plant Layout **$60**
Course No. 14 — Oct. 24-26 — Chicago

Metallurgy of Light and Copper-Base Alloys **$60**
Course No. 15 — Nov. 7-9 — Chicago

Sand Control & Technology **$60**
Course No. 16 — Dec. 5-7 — Detroit

REGISTRATION NOW OPEN. Make reservations for all 1960 AFS-T&RI training courses by course numbers and dates given. Registrations accepted in order as received at AFS Headquarters, Golf & Wolf Roads, Des Plaines, Ill.

Discussing metallurgy of ferrous alloys course presented during February by the AFS-Training & Research Institute in Chicago are instructors **Prof. Robert V. Wolf,** Missouri School of Mines and **C. G. Mickelson,** American Steel Foundries (both standing). Seated are students **E. P. Sitarz,** Prospect Foundry, Inc.; **Jerome Pardo,** Harry W. Dietert Co.; and **E. J. Fernadez,** Plainville Casting Co.

AFS-T&RI Gating & Risering Course Links Theory with Actual Problems

■ Does the grass always look greener on the other side? It did to foundrymen attending the AFS Training & Research Institute *Gating and Risering* course, Feb. 3-5 in Chicago, when they advanced solutions to practical problems submitted by others attending the course.

Drawing upon their own backgrounds and the course material presented by experts in the field, foundrymen were able to suggest solutions to many of these bottlenecks.

Another step in the linking of the theoretical with the practical was the study of a specific molding problem. Students were divided into steel, gray iron and non-ferrous groups and each given the same problem which was the molding pattern for the 1959 Apprentice Contest. The groups studied and analyzed the pattern for gating and risering and submitted reports. Recommendations were advanced for making the casting from the metal of their group. Winning entries in the Apprentice Contest were then shown to illustrate how the nation's top beginners had attacked the problem in 1959.

Among subjects covered in the course were basic fundamentals of heat transfer and fluid flow, flow patterns in horizontal and vertical gating systems and mold cavities, gating and risering of ferrous castings and non-ferrous alloys.

Instructors were Dr. W. K. Bock, National Malleable & Steel Castings Co., Cleveland; Prof. J. F. Wallace, Case Institute of Technology, Cleveland; R. A. Colton, American Smelting & Refining Co., Houston, Texas; AFS-T&RI Director S. C. Massari and AFS-T&RI Training Supervisor R. E. Betterley.

In addition to the lectures, three movies were shown. "Metal Flow in Molds" by the Institute of British Foundrymen and the AFS films "Effect of Horizontal Gating Design on Casting Quality" and "A Study of Vertical Gating Design."

At the close of the course Betterley conducted a brief test covering important points discussed.

AFS-T&RI Maintenance Course Attended by 37 in Birmingham

■ Thirty-seven foundrymen from the southeastern region attended the *Preventive Maintenance* course, co-sponsored by the AFS Birmingham Chapter and the AFS Training & Research Institute. The three-day course was held Feb. 15-17 at the Hotel Thomas Jefferson, Birmingham, Ala.

The course stressed the development of preventive maintenance philosophy and how to set-up and administer a preventive applications program. In addition, considerable attention was given to the specific problems of molding and core machines and ventilation, air and safety.

R. E. Betterley, T&RI Training Supervisor, conducted the orientation session and an achievement test in reviewing the course material.

S. C. Massari, T&RI Director, discussed equipment operating problems involved in melting, heat treating, cleaning as well as lifting equipment.

Richard Allchin, Rotor Tool Co., Cleveland, and Warren Rhoades, Cooper-Bessemer Corp., Dallas, Texas, outlined operating problems involved in compressed air systems and tools. Instructions on hand tools were supplemented with the presentation of a sound movie.

William D. Lee, General Electric Co., Schenectady, N. Y., dealt with the problems encountered with electrical equipment and controls and showed a sound film on "Productive Maintenance".

K. M. Smith, Caterpillar Tractor Co., Peoria, Ill., explained how to set-up and operate an effective maintenance program. Discussion also included problems and solutions encountered in materials handling equipment.

George Koren, Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago, covered the field of molding and core machines with recommendations advanced for the lubrication, inspection and scheduling of maintenance work.

H. J. Weber, AFS Director of Safety, Hygiene & Air Pollution Control Program, discussed ventilation, air and safety, including safety-maintenance relationship, dust collectors, fans and blowers.

V. M. Rowell

T. W. Seaton

Head Division

■ Victor Rowell, Federal Foundry Supply Div., Archer-Daniels-Midland Co., Cleveland, and formerly Vice-Chairman of the Sand Division has been named as Chairman of the Division succeeding L. J. Pedicini, Knight Engineer Est., Zurich, Switzerland, who resigned.

T. W. Seaton, American Silica Sand Co., Ottawa, Ill., has been elected as Division Vice-Chairman.

Shell Course Set for April 11-13

■ One April course, *Shell Molds and Cores,* will be presented in April by the AFS-Training & Research Institute. The course will be held April 11-13 in Chicago. No classes will be held during May due to the 64th Castings Congress & Castings Exposition.

Activities will resume June 1-3 at Indianapolis with the AFS Central Indiana Chapter co-sponsoring *Preventive Maintenance. Production of Ductile Iron* will be held June 27-29 at Chicago followed by *Blueprint Reading and Estimating,* July 11-13 in Chicago, and *Cupola Melting of Iron,* July 25-29 at Chattanooga, Tenn., in cooperation with the AFS Tennessee Chapter.

The courses in Chicago will be attended by 33 students, with the average student likely to be a foundry foreman, superintendent, metallurgist or engineer, according to figures compiled on the first three years of AFS-T&RI operations.

Figures show that during this time 36 courses were attended by 1152 students—1031 Americans, 111 Canadians and 10 foreign foundrymen.

Foundries to date have accounted for more than 81 per cent of companies sending students to courses.

When established, the AFS-T&RI courses were intended mainly for foundry middle supervision. Figures show that more than 70 per cent of the foundrymen-students attending the courses fall into this classification.

Members of the Executive and Programs and Papers Committees of the **Die Casting & Permanent Mold Division** at February meeting in Chicago. Left to right: **F. C. Bennett,** Dow Chemical Co., Midland, Mich.; **H. E. Eriksen,** Chrysler Casting Plant, Kokomo, Ind.; **L. W. Wickson,** Centr-O-Cast & Engineering Co., Detroit; **C. B. Curtis,** Maytag Co., Newton, Iowa; **P. D. Frost,** Battelle Memorial Institute, Columbus, Ohio; **W. J. Grassby,** Bendix Products Div., Bendix Aviation Corp., South Bend, Ind.; **J. W. Meier,** Dept. of Mines & Technical Surveys, Ottawa, Ont., Canada; **D. L. Colwell,** Apex Smelting Co., Cleveland; AFS Technical Director **S. C. Massari; Nicholas Sheptak,** Dow Metal Products Co., Div. Dow Chemical Co., Midland, Mich.; **R. P. Dunn,** Lindberg Engineering Co., Chicago.

Members of the **Brass & Bronze Division** Executive and Program & Papers committees met in February to discuss the division's activities at the 64th Castings Congress. The program will include two technical sessions, a seminar and round-table luncheon.

Details for the **Malleable Iron Division** panel discussion of "Malleable Straightening Dies" was discussed at the February meeting of the division's committee on finishing and inspection. Attending were: Chairman **O. K. Hunsaker,** Dayton Malleable Iron Co., Dayton, Ohio; **L. E. Sutton,** John Deere Malleable Iron Works, East Moline, Ill.; **R. W. Leppien,** Central Foundry Div., GMC, Saginaw, Mich.; **W. L. Olsen, Jr.,** Wagner Casting Co., Decatur, Ill.; AFS Technical Director **S. C. Massari; A. R. Lindgren,** Magnaflux Corp., Chicago; **Nick Zitto,** Auto Specialties Mfg. Co., St. Joseph, Mich.

Russian to Speak at Sand Dinner

■ Dr. Y. A. Nekhendzi, Head of Chair of Foundry Production, Leningrad Polytechnic Institute, Leningrad, Russia, will be the speaker at the Sand Division dinner to be held May 10 during the 64th Castings Congress & Exposition. The dinner will be held in the Crystal Ballroom, Benjamin Franklin Hotel. Tickets are $6.

Society will Buy Old Transactions

■ High demands by members for past copies of AFS Transactions has reduced the Society's stock on many issues. In order to replenish its inventory, AFS will pay $5 for each used Tranactions in good condition except for the following volumes; 54(1946), 63(1955), 65(1957), 66-(1958) and 67(1959).

Members having copies in good condition are asked to communicate with the Book Department, American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill., for authority to ship.

Outline Principles of Ferrous Alloys

■ An outstanding staff of volunteer teachers guided foundrymen-students through the three-day *Metallurgy of Ferrous Metals* course presented February 22-24 at the Hamilton Hotel, Chicago, by the AFS-Training & Research Institute.

Donating their time as instructors were Prof. Robert V. Wolf, Missouri School of Mines, Rolla, Mo.; Prof. R. W. Heine, University of Wisconsin, Madison, Wis.; C. G. Mickelson, American Steel Foundries, East Chicago, Ind.; W. D. McMillan, International Harvester Co., Chicago; S. C. Massari, AFS-T&RI Director and R. E. Betterley, AFS-T&RI Training Supervisor.

Included in the course were such fundamentals as physical metallurgy of metals, iron-carbon alloys, basic micro-constituents in ferrous alloys, types of heat treatment and basic characteristics and behaviors of ferrous cast metals.

chapter news

Honor Walter Seelbach for 50-Year Service

Seven prominent gray iron foundrymen at Cleveland meeting, March 10: (from left) **C. H. Ker, F. J. Dost, Henry Trenkamp, Seelbach, C. R. Culling, H. L. Good, A. E. Hageboeck.** All except Dost are past presidents of the Gray Iron Founders Society.

Four AFS past-presidents at March 10 meeting: **Frank Shipley,** Caterpillar Tractor Co., **E. W. Horlebein,** Gibson & Kirk Co.; **W. L. Seelbach,** Superior Foundry, Inc., **F. J. Dost,** Sterling Foundry Co.

■ Over 250 foundrymen gathered March 10 at the Northeastern Ohio Chapter's "Walter Seelbach Nite" to honor AFS past President Walter L. Seelbach, president of Superior Foundry, Inc., Cleveland, for 50 years of devoted foundry service. In a special program preceding the regular technical session, tribute was paid the guest of honor as a "Foundryman of Distinction."

In describing Seelbach's long career of service to the castings industry, Chapter Chairman Al Hinton, Aluminum Co. of America, said: "Few men have served the industry so long and in so many ways, or have given so much of themselves to advance it . . . frequently, competently, unselfishly."

Two thick portfolios with over 150 letters of tribute were presented from AFS and the Gray Iron Founders Society. C. R. Culling, Carondelet Foundry Co., St. Louis, presented the latter. Frank W. Shipley, Caterpillar Tractor Co., Peoria, Ill., presented the AFS testimonials. Chairman Hinton gave Seelbach an engrossed resolution signed by the Chapter's officers and directors. AFS General Manager Wm. W. Maloney presented a 50-year Service pin and a set of jewelry "from the Central Office Staff."

The many out-of-town guests included more than 30 past or present national officers and directors of AFS and the Gray Iron society. In describing Walter Seelbach's services to the foundry industry, Chairman Hinton outlined his career from March 10, 1910 when he first entered the industry as timekeeper for the former Walworth Run Foundries. Today Seelbach is president and board chairman of Superior Foundry and its Allyne-Ryan Foundry division, acquired in 1959.

Walter Seelbach's association activities include: president 1926 of Ohio Foundrymen's Association; an organizer and first president (1928) of former Gray Iron Institute; president of G.I.F.S. 1943-44, director for 13 years, and recipient of the 1946 citation and 1951 gold medal; AFS director 1935-1938, and president 1951-52, presiding at the 1952 International Foundry Congress in Atlantic City.

Seelbach has served on numerous foundry committees advisory to Government agencies since 1932, has been active in F.E.F. and Cleveland civic affairs, and in 1947 was named to Cleveland's "Hall of Fame."

AFS past president **Frank Shipley** presents portfolio of testimonial letters to **Walter Seelbach** at Cleveland meeting.

Chicago Chapter's Education Committee which arranged the series on Supervision—Key to Foundry Progress, given in March. Left to right **Jim Downs,** American Steel Foundries, **Marshall Wells,** Wells Mfg. Co. and chairman **John Harwood,** Standard Foundry Co., Racine, Wis.

Patternmakers at the February meeting of the **Chicago Chapter** heard **Wayne Wright,** Woodruff & Edwards Co., shown on left, discuss shell equipment. On right is technical chairman **Bob Swanson,** Arrow Pattern Foundry Co.

Although it meant driving 70 miles each way, **Frank Waltz** and **Timothy Leary,** Pennsylvania Malleable Iron Corp., Lancaster, Pa., attended the **Philadelphia Chapter** meeting in January on work simplification.

—Leo Houser & E. C. Klank

Northwestern Pennsylvania Chapter

Schedules Castings Symposium

■ Two symposiums on casting defects will be held April 11, 12 with a panel of five members conducting the discussion. The program is sponsored by the Education Committee headed by W. J. Willmot, Urick Foundry Co., Erie, Pa.

New foundry core processes were explained to the **Central New York Chapter** in January by **R. J. Mulligan,** Archer-Daniels-Midland Co. Processes covered included new applications of the CO_2 process, air-setting binders and techniques, self-curing systems and new resins for shell core techniques. Also mentioned was the possible use of flue gas as a replacement for the CO_2 process. —**Lewis Balduzzi**

Casting of aluminum alloys in permanent molds was discussed at the January meeting of the **Northern California Chapter** by Howard Heath, Aluminum Co. of America. Shown are speaker **Heath,** Chapter Vice-President **Hugh Prior,** Superior Electrocast Foundry; Chapter President **Donald C. Caudron,** Pacific Brass Foundry of San Francisco and assistant program chairman **M. E. Ginty,** Vulcan Foundry Co. —**R. J. Ritelli**

John Dusthimer, Keener Sand & Clay Co., Columbus, Ohio, and chairman of dance committee of the Central Ohio annual winter party, presents door prize to **Mrs. Tom Cusack.** Other door prize winners were Mrs. J. W. Kent, Mrs. Virginia Moone, Mrs. Ty Helen and Mrs. Nard Stapf. —**Joe Riley**

Final check prior to the start of the technical sessions of the **Chicago Chapter** February meeting are being made by technical chairman **Chuck Fausel,** Chicago Foundry Co.; Chapter Chairman **John Mulholland,** Pettibone-Mulliken Corp., and speaker **Fred Kasch,** Gray Iron Research Institute, who spoke on "Various Analyses Irons from a Single Cupola Heat."

Use of the carbon arc process in cleaning castings was explained to members of the **Chicago Chapter** in February by **Elmer Lemcule,** Arcair Co.

Saginaw Valley

Refractories Panel Discussion

■ Refractory practice in Saginaw Valley area foundries was discussed at the January meeting. Topics included:

- Cupolas—Melting zones, upper sections, slag holes, bottoms, breasts and front-slagging set ups.
- Hot metal receivers or forehearths —Spouts, bottoms, sidewalls and tops.
- Electric furnaces—Roofs, sidewalls and bottoms.
- Ladles.

Panelists were Thomas Pavlovich, Buick Motor Div., GMC, Flint,Mich.; Romaine Boughner, Chevrolet-Saginaw Grey Iron Foundry, Saginaw, Mich.; Larry Zinsmeister, Eaton Foundry Div., Vassar, Mich.; Leon Cline, Saginaw Foundries Co., Saginaw, Mich.; Francis Howard, Saginaw Malleable Iron Plant, Central Foundry Div., GMC, Saginaw, Mich.; William Barker, Vally Steel Castings, Bay City, Mich. —*John R. Fraker*

Participants in **Saginaw Valley's** panel discussion on refractory practices shown with Chapter Officers at head table.

New England Vice-President P. C. Smith, General Electric Co., Everett, Mass., and **E. M. Hanauer,** General Electric Co., New York, who addressed chapter on fire prevention. —**F. S. Holway**

An outstanding job on chapter membership has been done by the **Tri-State Chapter.** Shown are **Kenneth Stuerman,** Walsh Refractories; Kenneth Kimball, Kimball Chemical Co.; Membership Chairman Carl Townsend, Oklahoma Steel Castings Co. Div., American Steel & Pump Corp.

Washington Chapter

Quality with Vacuum Melting

■ Improvements in properties of various steels with ingots produced by vacuum induction melting, especially consumable electrode melting, were described at the February meeting by William J. Baldwin, Allegheny Ludlum Steel Corp.

While there is not always great improvement in tensile and yield, there is usually a considerable improvement in reduction of area, elongation, impact properties and fatigue resistance with vacuum melted steel. Data was presented to show superior properties with the consumable electrode method, especially where segregation, impurities and gas content are a problem. The process is ideal for the production of steel containing 3 per cent titanium with considerable aluminum, as the titanium would segregate in air-poured steel. The transverse and longitudinal strengths are the same in shapes rolled from the consumable produced ingots.

—*Hubert L. Rushfeldt*

. . . . and They Said It Couldn't Be Done

■ Pouring of castings in downtown Milwaukee was the Wisconsin Chapter's bid for local publicity on the Wisconsin Regional Foundry Conference and the Chapter's 25th anniversary. Despite the winter's worst storm, molten aluminum was trucked in from Lawran Foundry Co. and castings poured as scheduled. P. S.–These pictures appeared in the local press.

Chairman **L. J. Andres** and Vice-Chairman **B. H. Booth** examine casting with **C. G. Crabb,** Milwaukee Chamber of Commerce. Below—Foundry Sidewalk Superintendents, Wisconsin Div., approve proceedings.

Central Illinois Chapter

Process of Solidification

■ The process of solidification as it relates to gating and feeding was explained at the February meeting by B. C. Yearley, National Malleable & Steel Castings Co., Cleveland.

Among points covered by Yearley were: Steel and white iron are skin forming metals . . . Steel shrinks 3 per cent–white iron 4-1/2 per cent . . . A shrink indicates the last place in the casting to freeze . . . Fillet radii should be equal to section thickness . . . Design which gives least trouble in shrinkage has been proved to be best designed to withstand failure due to fatigue and stresses . . . As a rule, chills should be the same thickness as the casting section to be chilled . . . Feeders near the edge of the flasks will be less efficient since they will cool fast . . . There is no excuse for a defective casting from shrinkage if it is designed properly.

–C. H. Bavis

Cincinnati Chapter

Producing Good Ductile Iron

■ An illustrated lecture on the production of ductile iron was presented at the February meeting by C. K. Donoho, American Cast Iron Pipe Co., Birmingham, Ala.

C. K. Donoho

The speaker first traced the early history and then illustrated the metallographic structures and physical properties obtained by various treatments. Also discussed were properties and the factors affecting quality, such as base composition, chemistry, optimum magnesium content and temperatures. Typical applications and current techniques for making ductile iron castings were explained.

–Stanley F. Levy

Tri-State Chapter

Non-Ferrous Foundry Practice

■ Principles of gating, risering and melting practices were explained by Ray Cochran, R. Lavin & Sons, Inc., at the February meeting attended by 50 chapter members. AFS National Director Jake Dee, Dee Brass Foundry, Inc., Houston, Texas, explained the operations of the AFS-Training & Research Institute program.

–Frank M. Scaggs

Western Michigan Chapter

Three Speakers in February

■ Sessions on refractories, coke and patterns were conducted at the February meeting. "Coke from Oven to Foundry" was explained by John G. Howard, Demet-Solvay Div., Allied Chemical Corp. "Planned Pattern Program for Quality Castings" was presented by R. L. Olson, Dike-O-Seal, Inc., Chicago and "Super Refractories" were discussed by R. M. Keefe, H. K. Porter, Refractories Div.

–John R. McNamara

New England Chapter

Hears Fire Prevention Talk

■ If a fire strikes in your plant you probably will have not only a ruined building but also a fortune in ruined machines and equipment. The finest fire department can do nothing to save what has already been burned or spoiled before their arrival. If the fire has gained considerable headway, it is doubtful they can make a fast stop.

Your very best fire insurance is to stop a fire before it starts, and the next best thing is to have employees trained to hold back a fire until the fire department arrives.

These were comments of Ernest M. Hanauer, General Electric Co., New York, who spoke to the New England Chapter in February. Hanauer illustrated several of his points with demonstrations.

–F. S. Holway

British Columbia Chapter

Aluminum in Permanent Molds

■ Melting practice, mold operating techniques, progressive solidification and other key factors were stressed by Howard Heath, Aluminum Co. of America, at the January meeting. Chapter Chairman Norman D. Amundsen, Terminal City Iron Works, presided with Vice-Chairman Henry Bromley, Letson & Burpee, Ltd., serving as technical chairman.

–J. B. Hopkinson

Wentworth Institute students in January heard William G. Parker, General Electric Co., Elmira, N. Y., explain the relation between casting defects and sand properties. Shown are foundry instructor **F. J. Boylan;** industrial advisor **H. H. Klein;** speaker **Parker;** and Wentworth Dean, **Carl A. Swanson.** In an illustrated lecture, Parker stressed that a study of sand behavior in molds will lead to improved castings. **—M. Faine**

Central New York's January meeting was devoted to a discussion of new foundry core processes by **R. J. Mulligan,** Archer-Daniels-Midland Co. Despite inclement weather, 75 members attended the meeting held at Drumlin country club, Syracuse, N.Y. Chapter Chairman Bruce Artz, Pangborn Corp., presided.

—Lewis Balduzzi

Among those present at the January meeting of the **Western New York** Chapter were **Nick Kowal,** Pratt & Letchworth Co.; Secretary **Ron Turner,** Queen City Sand & Supply Co.; **Jerry Goetz,** Sterling National Industries, Inc.; **Walter Napp,** Milwaukee Chaplet Co.; **Buck Santomieri,** Worthington Corp.; and Chapter Chairman **E. J. O'Connell,** American Radiator & Standard Sanitary Corp.

—Don Kruedor

Metal solidification was discussed at the **Philadelphia Chapter's** February roundtable discussion. Left to right: iron—**C. W. Mooney, Jr.,** Olney Foundry Div., Link-Belt Co.; Chapter Chairman **E. A. Zeeb,** Dodge Steel Co.; brass—**D. E. Best,** Bethlehem Steel Co.; **steel—S. Donner,** Deemer Steel Castings Co. **—Leo Houser, E. C. Klank**

Past Chairmen of the **Eastern Canada Chapter: P. Von Colditz,** 1957-58; **C. Bourassa,** 1954-55; **J. Newman,** 1949-50; **A. Cartwright,** 1947-48; **E. Tait,** 1945-46; **R. W. Bartram,** 1942-43; **A. J. Moore,** 1952-53; **H. Louette,** 1946-47; **L. Guillemette,** 1950-51; **W. C. H. Dunn,** 1955-56; **M. McQuiggan,** 1956-57; **Max Reading** 1958-59. **—J. W. Cherrett**

Rochester Chapter

Report on Russian Visit

■ A report of metallurgical interest as well as overall impressions of a 1959 trip through Russia was given at the February meeting by Dr. Thomas B. King, associate professor of metallurgy, Massachusetts Institute of Technology.

Dr. King's trip included visits to Moscow, Leningrad, Zagorsk and Tulsa. The talk was supplemented by colored slides. *—Haerle Wesgate*

Canton Chapter

Sand and Mold Quality Control

■ Mold hardness is of the utmost importance in determining the quality and dimensional accuracy of castings. E. H. King, Hill & Griffith Co., Cincinnati, told Canton foundrymen at their February meeting.

King emphasized the importance of daily control over various properties of sand mixes. He also explained with a chart how to determine effective clay content of a sand mix through green shear and green compressive strength testing.

—Charles Stroup

Birmingham Chapter Chairman J. R. Cardwell, Stockham Valves & Fittings, Inc., Birmingham, Ala., accepts bell cast by members of the University of Alabama Student Chapter. Making the presentation is Student Chapter Chairman **T. T. Bales.** The bell was presented to the Birmingham Chapter in appreciation for its assistance to the students.

Clyde Sanders, right, speaker at the January meeting of the **Western New York** Chapter, emphasizes point to **Al Petz,** Symington Gould Div., Symington-Wayne Corp.

—Don Kreuder

Foundry mechanization was explained at the February meeting of the **Eastern Canada** Chapter by **J. Bertrand**, Lester B. Knight & Associates, Chicago. Shown at head table are **E. Landry, B. Laurin**, speaker **Bertrand**, Chapter Chairman **A. H. Lewis, J. Dick, A. Durrell, L. Myrand** and **G. Tracy.** —**J. W. Cherrett**

Simultaneous sessions were conducted at the February meeting of the **Michiana** Chapter. **K. E. Blessing,** left, Wheelabrator Corp., spoke on air pollution control with the cupola and the electric furnace. **N. R. Sailor,** Northern Indiana Brass Co., right, spoke on ways and means of reducing cost and controlling quality in the brass foundry. In center is Chapter Chairman **Robert Hull.** —**A. J. Stanczyk**

Winners of the **Oregon Chapter** apprentice contest: **Lee Vachter,** Pacific Steel Foundry Co., steel molding; **Norbert Aicher,** Willamette Pattern Works, wood patternmaking; **Raymond Souders,** Northwest Foundry Co., iron molding; **Donald Nealeigh,** Oregon Brass Works, non-ferrous molding. Apprentice winners received savings bonds from the chapter.

Attending the February meeting of the **Western New York Chapter** were **S. Santamieri,** Worthington Corp.; **Sam Steel,** Ingersol-Rand Co.; **Al Petz,** Symington Gould Div., Symington-Wayne Corp.; **Jack Benedict,** Queen City Sand & Supply Co.; **Marty Kerkowitz,** Symington Gould Div., Symington-Wayne Corp.

Attending the Southeastern Regional Foundry Conference held in February in Birmingham, Ala., were: Director Nominee **Warren C. Jeffrey,** McWane Cast Iron Pipe Co., Birmingham, Ala.; National Director **N. N. Amrhein,** Federal Malleable Co., West Allis, Wis.; National Director **Clyde A. Sanders,** American Colloid Co., Skokie, Ill.; National Director and former AFS President **L. H. Durdin,** Dixie Bronze Co., Birmingham.

Oregon Chapter

Honor Apprentice Winners

■ Savings bonds were awarded at the February meeting to the four first place winners in the chapter's apprentice contest. Sixteen entries were received in four categories; iron molding, steel molding, non-ferrous molding and wood patternmakers.

Winners were: Lee Vachter, Pacific Steel Foundry Co.; Norbert Aicher, Williamette Pattern Works; Raymond Souders, Northwest Foundry Co. and Donald Nealeigh, Oregon Brass Works.

W. G. Walkins

Bill Walkins, editor, *The Esco Ladle*, Electric Steel Foundry Co., spoke on employee relations. Said Walkins, "In this day of automation and bigness, it can become very easy to forget our most important asset–our people. Maintenance of good employee relations can be even more important than maintenance of the machines. Industry has an obligation to further high ethics and good principles; but even if this were not so, we have to treat people like people if we are to expect the most return from them."

–Norman E. Hall

Eastern Canada Chapter

Installing Foundry Mechanization

■ A foundry mechanization program will more than pay for its way, J. H. Bertram, Lester B. Knight & Associates, Chicago, informed chapter members at the February meeting. He emphasized that existing foundry facilitities should first be examined before mechanization is adopted with a study of such items as sand distribution, melting times, schedule system, flask size and man hours saved. Slides were shown on different mechanization installations.

The February meeting also honored past chairmen with each receiving a certificate of merit from Chapter Chairman Alf Lewis, Crestweld Mfg. Ltd. National Director A. J. Moore, Canadian Bronze, Ltd., summarized activities at the Central Office in Des Plaines, Ill.

A past chairmen group was formed with R. W. Bartram named as honorary chairman, H. Tate as chairman, M. Reading as secretary and J. Newman as head of the entertainment committee. *–J. W. Cherrett*

Attending **Ontario Chapter** meeting in January are: Chapter Director and publicity chairman **Vincent H. Furlong,** Foundry Services (Canada) Ltd.; AFS National Director **A. J. Moore,** Canadian Bronze, Ltd., Montreal; Chapter Chairman **Theodore Tafel III,** American Standard Products (Canada) Ltd.; **M. E. Hollingshead,** Archer-Daniels-Midland Co., Ltd. **—M. E. Hollingshead**

Attending January meeting of **Western New York** Chapter are **C. Skrzechzkowski, E. Deutschlander** and **Frank Majeski.**

E. H. King, February speaker at the Canton Chapter, shown with technical chairman **F. A. Dun,** Babcock & Wilcox Co.

Solidification as it relates to gating and feeding was described to the **Central Illinois** Chapter in February by B. C. Yearley, National Malleable & Steel Castings Co., Cleveland. Shown are Technical Chairman **L. R. Jenkins,** Wagner Castings Co.; speaker **Yearley** and former AFS President **Frank Shipley,** Caterpillar Tractor Co. **—C. H. Bavis**

Ed. Klank, Philadelphia Chapter Reporter, Philadelphia Coke Co., greets **Robert Jones,** Posey Iron Works, Lancaster, Pa., who traveled more than 70 miles to attend the chapter's round-table discussion in February. **—Leo Houser**

Donald Nealeigh, Oregon Brass Works, accepts savings bond as first prize in the nonferrous molding competition of the Oregon Chapter apprentice contest. Presenting bond is **Ralph Brossart,** Columbia Steel Castings Co., judging chairman.

Chicago Chapter's Annual Ladies Night held during February drew a large crowd including Mr. and Mrs. **Art Vandinberg** and Mr. and Mrs. **Charles Roe.**

Attending the **Chicago Chapter** Ladies Night in February were Mr. and Mrs. **Leo Dennie.** **—George DiSylvestro**

Anton Dorfmueller, speaker at the February meeting of the **Western New York Chapter,** threatens to cut-off tie of **Leonard Romano,** technical chairman. **—Don Kreuder**

Northeastern Ohio Chapter

Meets with Die Casting Engineers

■ Chapter members and members of the Cleveland Chapter, Society of Die Casting Engineers held a joint meeting in January.

Walter Bonsack, Aluminum & Magnesium, Inc., Sandusky, Ohio, discussed *Metallurgical Factors in the Preparation of Aluminum Alloys for Permanent Molds & Die Casting.* He pointed out that sand casting is primarily a batch methods whereas permanent mold and die casting are essentially continuous operations. Otherwise, melting is basically the same. The difference is important, however, in that the metal mold processes require a continuous supply of metal at constant quality and temperature.

Gene Passman, Frederic B. Stevens, Inc., Detroit, addressed the ferrous session on *Use and Abuse of Core and Mold Washes.* Core and mold washes are essentially the same—consisting of a mineral base, western bentonite and oil or resin binders, in a water or solvent vehicle. Often they contain wetting agents or other additives for antifoaming, flattening, pH control, or for other desired characteristics.

Washes fall into two basic categories, those with a carbon base and those with some other mineral base. Many are combinations of these. Washes are used to obtain smooth casting finishes, clean peel of sand, and to prevent metal penetration. Washes for shell molds and cores require a wetting agent to obtain penetration and even coating. Those used on sodium-silicate sand mixes must have a solvent vehicle; water can not be used. Most casting defects attributable to washes result from a wash that is too thin, too thick, or does not get proper anchoring to the sand surface.

Washes should not be used unless they are necessary. They are not a panacea and are not to be used in place of good sand practice.

—Robert H. Herrmann and Jack C. Miske

Central New York Chapter

Malleable Iron Production

■ Melting and melting equipment used in straight air furnace production of malleable iron was discussed at the February meeting by Russell Sawyer, Fraser & Jones Co., Syracuse, N. Y.

R. Sawyer

The illustrated talk stressed the operating problems as well as equipment involved. Photomicrographs were also shown of the internal structure of both standard and pearlitic malleable irons. Seventy - five members attended the meeting with Chairman Bruce Artz, Pangborn Corp., Syracuse, N. Y. presiding.

—Lewis Balduzzi

Detroit Chapter

Challenge to Gray Iron

■ A challenge to gray iron foundrymen to take advantage of new developments and utilize present facilities and processes to their fullest extent to meet the inroads of aluminum and the processes by which it was made by Clyde A. Sanders, American Colloid Co., Skokie, Ill., at the February meeting. Sanders stated that gray iron can compete with aluminum on a cost basis if full advantage is taken of producing high quality castings and if the two materials are compared on an equal basis.

C. A. Sanders

—J. R. Young

Mexico Chapter

Holds Election of Officers

■ Jose Ramon Albarran y Pliego, Fundidora de Aceros Topeyac, S.A. Santa Clara, Estado de Mexico, has been elected Chairman of the Mexico Chapter. Other officers are:

Vice-Chairman, Juan Latapi Sarre, Fundiciones de Hierro y Acero, S.A., Mexico, D.F., Mexico.

Secretary, Vincente Nacher Todo, La Consolidada, S.A., Mexico, D.F., Mexico.

Treasurer, Jose Amador Perez Casas, La Consolidada, S.A., Mexico, D.F., Mexico.

Directors, (Terms Expire 1963)—Enrique Leon Andrade, Teziutlan Copper Co., S.A., Mexico, D.F., Mexico. Manuel Goicoechea, Hierro Mall. de Mexico, S.A., Mexico, D.F., Mexico; Fernando Gonzalez Vargas, Teziutlan Copper Co., S.A., Mexico, D.F., Mexico.

Eastern New York Chapter

Magnesium and Cast Iron

■ The effect of magnesium and other alloying elements on the structure of ductile iron was explained at the February meeting by W. H. Northrup, International Nickel Co. Northrup emphasized the strength of ductile iron castings, a factor he said was not well recognized. Slides were shown on conversions to ductile iron from forgings and weldments.

—Leonard C. Johnson

Western New York Chapter

What's New in the Coreroom?

■ An explanation of the air-setting process was explained at the February meeting by Anton Dorfmueller, Archer-Daniels-Midland Co. The bond is a resin type, requiring no heat to cure . . . The molds or cores set ready to pour . . . Collapsibility is said to be very good with casting finish classed as good. *—Don Kreuder*

afs chapter meetings

APRIL

Birmingham District . . April 8 . . Thomas Jefferson Hotel, Birmingham, Ala. . . T. W. Seaton, American Silica Sand Co., *"Dry Sand Segregation."*

British Columbia . . April 22 . . Leon's, Vancouver, B.C. . . J. W. Smith, Oregon Metallurgical Corp., *"Vacuum Casting of Reactive Metals."* **. . April 30 . .** Birch Bay . . *Golf Outing.*

Canton District . . April 7 . . Roumanian Hall, Alliance, Ohio . . C. Winninger, Beardsley & Piper Div., Pettibone Mulliken Co., *"Sand Reclamation." Recognition Night.*

Central Illinois . . April 4 . . Vonachen's Junction, Peoria, Ill. . . G. DiSylvestro, American Colloid Co., *"Veining & Penetration."*

Central Indiana . . April 4 . . Athenaeum, Indianapolis . . F. S. Catlin, Magnaflux Corp., *"Good Fundamental Casting Design."*

Central Michigan . . April 20 . . Hart Hotel, Battle Creek, Mich . . . C. A. Sanders, American Colloid Co., *"Comments on Various Molding Methods."*

Central Ohio . . April 11 . . Shawnee Hotel, Springfield, Ohio . . K. M. Smith, Caterpillar Tractor Co., *"Preventive Maintenance."*

Chesapeake . . April 29 . . Engineers' Club, Baltimore Md. . . W. R. Jaeschke, Whiting Corp., *"Cupola Practice."*

Chicago . . April 4 . . Chicago Bar Association, Chicago . . *Pattern Group*: P. Ropp, Cincinnati Milling & Grinding Machine Co., *"Duplicating Equipment"; Maintenance Group*: R. Leon, Kensington Steel Co., *"A Workable P/M Program"; Steel Group*: *"Bull Session"; Iron Group*: N. O. Kates, Lindberg Steel Treating Co., *"Heat treatment of Gray Iron & Ductile Iron."*

Cincinnati District . . April 11 . . Alms Hotel, Cincinnati . . J. B. Caine, Consultant, *"Casting Design." Recognition Night.*

Connecticut . . April 26 . . Waverly Inn, Cheshire, Conn.

Corn Belt . . April 15 . . Marchio's Steak House, Omaha, Neb. . . W. R. Jaeschke, Whiting Corp., *"New Cupola Design & Operations."*

Detroit . . April 7 . . Wolverine Hotel, Detroit . . R. Sutter, Sutter Products, Inc., *"Past Experience & Future Developments of Shell Molding."*

Eastern Canada . . April 8 . . Mt. Royal Hotel, Montreal, Que. . . C. A. Sanders, American Colloid Co., *"What European Foundries Are Doing."*

Eastern New York . . April 19 . . Panetta's, Menands, N. Y.

Metropolitan . . April 4 . . Military Park Hotel, Newark, N. J. . . V. Rowell, Federated Foundry Supply Div., Archer-Daniels-Midland Co., *"Sand."*

Mexico . . April 25 . . Chapultepec 412, Mexico City, Mexico . . R. O. Calderon, Metalurgica Ortega, *"Ingot Mold Manufacture."*

Michiana . . April 12 . . Rumely Hotel, LaPorte, Ind. . . S. Hodler, Gartland Foundry, *"CO_2 Cores & Molds."*

Mid-South . . April 8 . . Hotel Claridge, Memphis, Tenn. . . A. J. Ball, Hewitt-Robins, Inc., *"Vibrating Conveyors—Their Application & Cost."*

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chapter meetings

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Mo-Kan . . April 14 . . Fairfax Airport, Kansas City, Kans. . . W. R. Jaeschke, Whiting Corp., *"New Cupola Design & Operation."*

New England . . April 13 . . University Club, Boston.

Northeastern Ohio . . April 14 . . Tudor Arms Hotel, Cleveland . . *Panel*: J. A. Terpenning, Archer-Daniels-Midland Co.; A. G. Hill, Durez Plastics Div., Hooker Chemical Co.; C. J. Jelinek, Cleveland Foundry, Ford Motor Co.; J. Parker, Spo, Inc. and M. Wolf, Standard Brass Foundry Co., *"Shell Cores & Molds."*

Northern California . . April 11 . . Spenger's Cafe, Berkeley, Calif. . . J. W. Smith, Oregon Metallurgical Corp., *"Vacuum Casting of Reactive Metals."*

Northern Illinois & Southern Wisconsin . . April 12 . . Beloit Country Club, Beloit, Wis.

Northwestern Pennsylvania . . April 25 . . Amity Inn, Erie, Pa. . . C. A. Sanders, American Colloid Co., *"A Look Toward Future Foundries."*

Ontario . . April 22 . . Seaway Hotel, Toronto, Ont. . . *Ladies' Night.*

Oregon . . April 20 . . Heathman Hotel, Portland, Ore.

Philadelphia . . April 8 . . Engineers' Club, Philadelphia . . A. Dorfmueller, Jr., Archer-Daniels-Midland Co., *"Which Core Process."*

Piedmont . . April 29 . . Governor Tyler Hotel, Radford, Va. . . P. H. Stuff, Ross-Meehan Foundries, *"Castings Vs. Weldments."*

Pittsburgh . . April 18 . . Webster Hall Hotel, Pittsburgh, Pa. . . E. E. Woodliff, Foundry Sand Service Eng. Co., *"Every Foundry Can Have Improved Sands."*

Quad City . . April 18 . . LeClaire Hotel, Moline, Ill. . . J. S. Schumacher, Hill & Griffith Co., *"Foundry Sands & Good Castings."*

Rochester . . April 5 . . Manger Hotel, Rochester, N. Y.

Saginaw Valley . . April 7 . . Fischer's Hotel, Frankenmuth, Mich. . . *Education Night.*

St. Louis District . . April 14 . . Edmond's Restaurant, St. Louis.

Southern California . . April 8 . . Rodger Young Auditorium, Los Angeles.

Tennessee . . April 29 . . Wimberly Inn, Chattanooga, Tenn.

Texas . . April 18 . . Angelina Hotel, Lufkin, Texas . . J. B. Caine, Consultant, *"Casting Design."*

Texas, San Antonio Section . . April 18 . . San Antonio Machine & Supply Co., San Antonio, Texas . . *"Safety."*

Timberline . . April 13 . . Denver, Colo. . . W. R. Jaeschke, Whiting Corp., *"New Cupola Design & Operation."*

Toledo . . April 6 . . Heatherdowns Country Club, Toledo, Ohio.

Tri-State . . April 8 . . Haliday Motel, Oklahoma City, Okla. . . *"Iron."*

Twin City . . April 12 . . Jax Restaurant, Minneapolis . . T. J. Trezek, Central Foundry Div. GMC, *"Preventive Maintenance."*

Utah . . April 12 . . Salt Lake City . . W. R. Jaeschke, Whiting Corp., *"New Cupola Design & Operation."*

Washington . . April 21 . . Engineers' Club, Seattle . . J. W. Smith, Oregon Metallurgical Corp., *"Vacuum Casting of Reactive Metals."*

Western Michigan . . April 4 . . Bill Stern's, Muskegon, Mich. . *Plant Visit at Brunswick Automatic Pin-Setting Division.*

Western New York . . April 23 . . Trap & Field Club, Buffalo, N. Y. . . *Ladies' Night—Annual Spring Dinner Dance.*

Wisconsin . . April 8 . . Schroeder Hotel, Milwaukee. . . *Gray Iron Group*: Z. Madacey, Beardsley & Piper Div., Pettibone Mulliken Corp., *"New Processes & Equipment for the Core Room"*; *Steel Group*: *"Cast Weld Fabrication"*; *Malleable Group*: G. DiSylvestro, American Colloid Co., *"CO_2 Cores for Malleable"*; *Non-Ferrous Group*: C. R. Polanski, Consultant, *"Molding Sands"*; *Pattern Group*: J. B. Ferguson, Allis-Chalmers Mfg. Co., *"New Coatings & Constructions for Patterns."*

MAY

Birmingham District . . May 20 . . Thomas Jefferson Hotel, Birmingham, Ala. . . *Panel on Modern Molding & Core Methods.*

Central Illinois . . May 2 . . Vonachen's Junction, Peoria, Ill. . . C. E. Westover, Westover Corp., *"Mechanization for Small Foundries."*

Central Indiana . . May 2 . . Athenaeum Indianapolis . . *Past Chairmen's Night.*

Central Ohio . . May 1 . . Shawnee Hotel, Springfield, Ohio . . *Round Table Discussion—Gray Iron*: J. E. Haller, James B. Clow & Sons; *Malleable*: R. F. Reetz, Dayton Malleable Iron Co.; *Steel*: G. B. Greenwood, Buckeye Steel Castings Co.; *Non-Ferrous*: P. Ritzer, Franklin Brass Foundry.

Chicago . . May 2 . . Chicago Bar Association, Chicago . . J. R. Irish, Texas Foundries, Inc., *"Short Cuts—Texas Way."*

Corn Belt . . May 20 . . Beatrice Country Club, Beatrice, Neb. . . *Annual Stag Party.*

Eastern Canada . . May 13 . . Mt. Royal Hotel, Montreal, Que. . . *Presentation of Winning Entries, Paper Writing Competition.*

Mexico . . May 23 . . Chapultepec 412, Mexico City, Mexico . . F. G. Vargas, University of Mexico and Instituto Politecnico, *"Possible Application of Metallurgical Blast Furnace & Oxygen Converter for Production of Castings in Mexico."*

Mid-South . . May 13 . . Hotel Claridge, Memphis, Tenn. . . L. S. Wilcoxson, International Nickel Co., *"Gray Iron Metallurgy."*

Mo-Kan . . May 19 . . Fairfax Airport, Kansas City, Kans.

Northeastern Ohio . . May 19 . . Tudor Arms Hotel, Cleveland . . *Recognition Night—Apprentices, Old Timers, AFS National Officers and Past Chairmen.*

Northern California . . May 16 . . *Plant Visitation.*

Ontario . . May 27 . . Royal Connaught Hotel, Hamilton, Ont. . . C. A. Sanders, American Colloid Co., *"Comparison of Molding Methods."*

Quad City . . May 16 . . LeClair Hotel, Moline, Ill. . . C. A. Koerner, Central Foundry Div., GMC, *"New Foundry Testing Methods."*

Saginaw Valley . . May 5 . . Fischer's Hotel, Frankenmuth, Mich. . . O. L. Crissey, General Motors Institute, *"Effective Human Relations in the Foundry."*

Texas, San Antonio Section . . May 23 . . Alamo Iron Works, San Antonio, Texas . . *Election of Officers.*

Twin City . . May 10 . . Jax Restaurant, Minneapolis . . D. E. Balzano, Ben Sadoff Iron & Metal Co., *"Scrap Is a Raw Material."*

Washington . . May 19 . . Tacoma Wash. . . *Plant Visitation, American Smelting & Refining Co.*

Western Michigan . . May 2 . . Bill Stern's, Muskegon, Mich. . . *"Foundry Flexibility."*

Western New York . . May 5 . . Sheraton Hotel, Buffalo, N. Y. . . *Annual Smorgasbord Meeting.*

Wisconsin . . May 6 . . Schroeder Hotel, Milwaukee . . C. A. Sanders, American Colloid Co., *"There's a Little Dutch in the Sand."*

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W. D. McMillan


E. J. Romans


T. T. Lloyd


S. C. Wassen


E. E. Staples

let's get personal

Donald A. Roemer . . . formerly foundry superintendent, Franklin-Balmar Corp., Baltimore, Md., has been named assistant plant manager. He was formerly chairman of the AFS Chesapeake Chapter and is currently secretary.

W. D. McMillan . . . supervisor of metallurgy, International Harvester Co., McCormick Works, Chicago, has retired. McMillan joined International Harvester in 1923 and was appointed as supervisor of metallurgy in 1949. He became an AFS Honorary Life Member in 1956 and served as an AFS National Director 1958-59.

Emil J. Romans . . . has been named foundry manager, Canton Malleable Iron Co., subsidiary, Penn Machine Co. Romans comes to the Canton, Ohio, company from National Malleable & Steel Castings Co., Cleveland, where he had served for the past 26 years, latterly as foundry superintendent.

Thomas T. Lloyd . . . has been named vice-president, manufacturing, Albion Malleable Iron Co., and will be in charge of operations at the company's Albion (Michigan) and Muncie (Indiana) divisions, the latter a recent acquisition. Other appointments for the Muncie operations: **Frank V. Jasienski,** formerly operations manager at Albion, will become plant manager at Muncie; **Donald I. Huisenga,** foundry superintendent at Albion will be plant superintendent at Muncie. Other changes are: **Richard H. Dobbins,** to plant manager, Albion; **C. Russell Baker** to chief engineer, Albion; **Roland H. Behling** to design engineer, Albion; **Wendall D. Dickmeyer** to plant superintendent, Albion; **James L. Snyder,** to controller, Muncie.

Stowell C. Wasson . . . staff vice-president and a director, National Malleable & Steel Castings Co., Cleveland, is retiring as vice-president. Wasson began his career with National Malleable as a trainee in the purchasing department of the company's Indianapolis plant in 1911. He was elected a director in 1947.

George F. Hodgson . . . has been named as director of research, Doehler-Jarvis Div., National Lead Co., research and development department, Toledo, Ohio. **Henry L. Byrne** has been appointed assistant to the chief engineer of the division, **Byron W. Koch** has been made chief product development engineer.

Elton E. Staples . . . has been named as president, Hevi-Duty Electric Co., Div. Basic Products, succeeding **Harold E. Koch** who will devote more time to his responsibilities as executive vice-president of Basic Products and president of Como-Cast Corp., a subsidiary of Basic Products. Staples has been Hevi-Duty general manager and served as vice-president of sales and sales manager of the firm's Chicago district.

John W. Brown, Jr. . . . is president of Brown Metals Engineering, Inc., Div. Brown Thermal Products Corp., Elyria, Ohio, formed for providing engineering assistance on plant layout, melting equipment and practice, metal handling, metallurgy and process control. **Arthur C. Buesing,** formerly with Gray Iron Research Institute, is vice-president. **F. T. Kaiser,** formerly with Modern Equipment Co., is director of engineering. Brown Metals Engineering will continue the sale of hot-blast heaters formerly handled by Brown Thermal Products Corp. J.W. Brown is also president of Brown Fintube Co., Brown Thermal Products Corp. and Brown Fintube Canada, Ltd.


J. W. Brown


Pat Dempsey

H. Robert Chase . . . will represent the Kelsey-Hayes Co. in western Pennsylvania, Ohio, West Virginia, Kentucky and Eastern Michigan with headquarters in Cleveland. **Finley K. Heyl** will have headquarters in Chicago covering western Michigan, Indiana, Illinois, Wisconsin and seven other midwest states. **Robert Nielsen,** headquartered in New York, will be the eastern seaboard representative from Maine to Florida.

Fred Goerke . . . formerly superintendent, Standard Buffalo Foundry Co., Buffalo, N.Y., is now pattern shop superintendent, Fremont Foundry Co., Fremont, Ohio.

Patrick E. Dempsey . . . for four years chief metallurgist with Kensington Steel Co., Chicago, is now division metallurgical engineer in charge of technical services at the Gary Works, U. S. Steel Corp.

Richard A. Flinn . . . professor of metallurgical engineering, University of Michigan, Ann Arbor, Mich., has been granted a sabbatical leave for the 1960-61 second semester so that he may revise two text books.

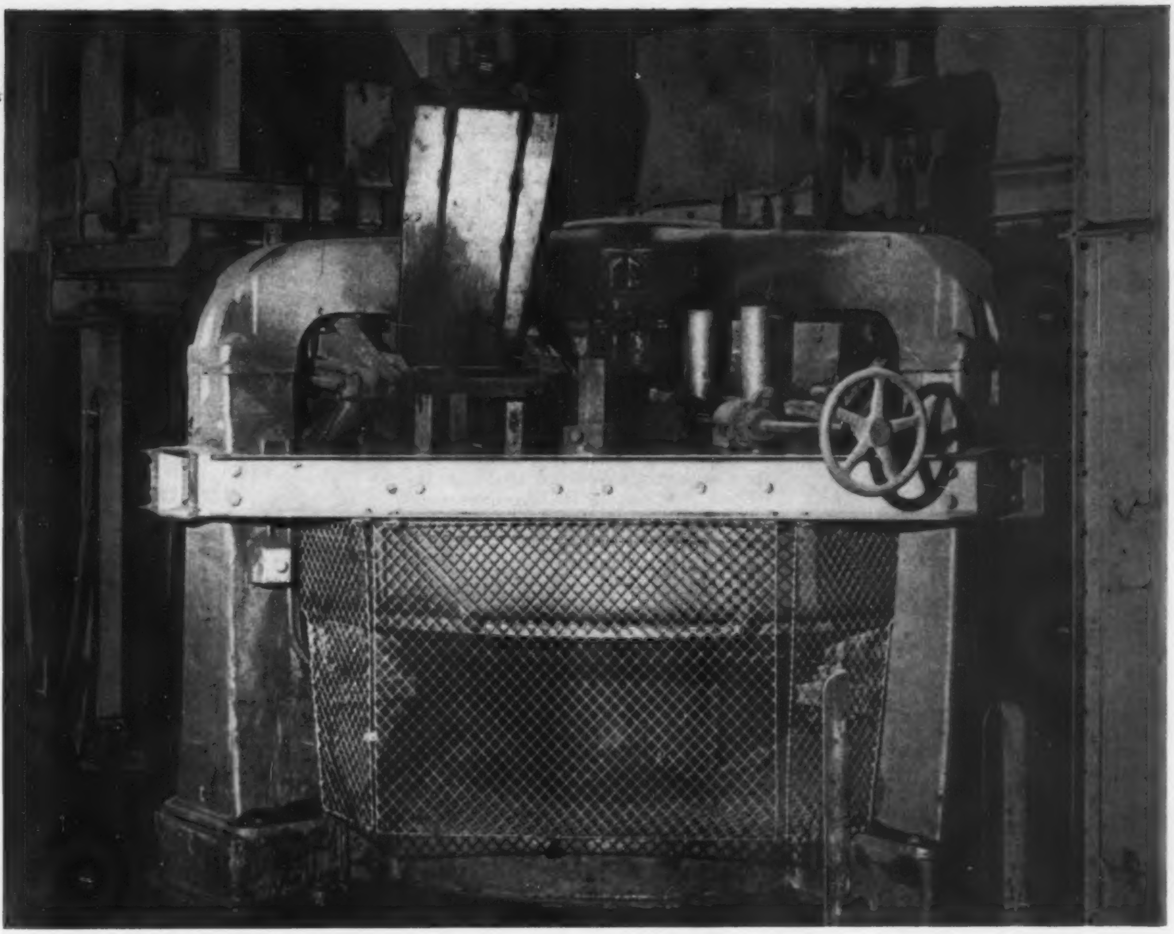
Manley Brooks . . . Bay City Plant, Dow Chemical Co., has been selected to receive the annual Penn State Distinguished Alumnus award in May. This award, known as the David Ford MacFarland award, is presented annually by the Penn State Chapter of the American Society of Metals to an alumnus who has distinguished himself. Brooks received the AFS Award of Scientific Merit in 1957.

Philip F. Gray, Jr. . . . and **Thomas R. Elmblad** have been named managers of the Boston and Cleveland district sales offices of Whiting Corp., Harvey, Ill. Gray moves from the sales staff of the New York domestic office and Elmblad from the Pittsburgh office. J. A. McGlone has been named sales manager of the Whiting Trambean Overhead Material Handling Systems, moving from Chicago sales to the home offices at Harvey. **B. L. Heinen,** formerly of the Houston office, has been transformed to Chicago. **R. A. Rogers** has been transferred to the Charlotte office from Chicago.

Conrad A. Parlanti . . . inventor of the Parlanti mold process, and president, Niforge Corp., Boston, is now making available his services as a metallurgical and foundry consultant.

S. Eugene Weed . . . has been appointed director of research and development at Vesuvius Crucible Co., Swissvale, Pa., succeeding **Charles A. Styer** who retired.

Continued on page 136



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let's get personal

Continued from page 134

Chester Otto . . . is now general foundry foreman of the Vilter Mfg. Co., Milwaukee. Otto joined Vilter Mfg. Co. in 1946.

Robert D. Clark . . . is now president, Northern Malleable Iron Co., St. Paul, Minn., succeeding **George T. Boli** who becomes chairman of the board. **Donald B. Fulton** has been advanced from vice-president of manufacturing to vice-president and general manager. Fulton and **Thomas Kirby**, sales vice-president, were made directors.


R. D. Clark


R. L. McIlvaine

R. L. McIlvaine . . . executive vice-president, National Engineering Co., Chicago, and Vice-Chairman of the AFS Safety, Hygiene & Air Pollution Control Program Steering Committee, attended the President's Conference on Occupational Safety held March 1-3 in Washington, D. C.

Myron C. Williams . . . has been appointed to the sales staff of Roessing Bronze Co., Pittsburgh, Pa. Williams, previously senior analyst with Goodyear Atomic Corp., Piketon, Ohio, will handle Roessing product sales and services throughout Ohio.

Everett G. Couch, Jr. . . . has been named production manager for Chas. Taylor Sons Co., Cincinnati, a subsidiary of National Lead Co. He was manager of the firm's refractories plant at Taylor, Ky. **Raymond B. Lippincott, Jr.**, has been named as plant manager at Taylor, Ky. He was formerly with Sayre & Fisher Brick Co., Sayreville, N. J.

Lee Nelsen . . . formerly foundry superintendent, Metals Processing Div., Curtiss-Wright Corp., is now general foundry foreman of Strong Steel Foundry Co., Buffalo, N. Y.

William Busby . . . has been elected a vice-president of Texas Foundries, Inc., Lufkin, Texas. He has been with Texas Foundries for 11 years, serving as chief engineer since 1958.

Austin D. Vanderbilt . . . has been named manager, industrial engineering for Crouse-Hinds Co., Syracuse, N. Y. He will coordinate the work of the plant engineering, planning, standards, quality control and safety departments.

William Welsh . . . formerly with Pusey & Jones Corp. Wilmington, Dela., is now assistant foundry superintendent, DeLaval Steam Turbine Co., Trenton, N.J.

William J. MacNeill . . . has been named to the newly created position of works manager, Federal Malleable Co., Milwaukee. For the past two years has been associated with Westover Corp., Milwaukee, as a foundry consultant.

Bengt R. F. Kjellgren . . . has been elected as chairman of the board of Brush Beryllium Co., Cleveland, and **George S. Mikhalapov** has been named as president. Kjellgren, who had been president since 1948, will continue to be the chief executive officer. Mikhalapov has been executive vice-president since he joined the company in 1957. **C. Baldwin Saywer**, who has been board chairman, becomes chairman of the executive committee of the board.

J. A. Pierce . . . member of the technical sales department, Harbison-Walker Refractories Co., Pittsburgh, has been named as manager.

John E. Benedict . . . has been appointed sales representative for Queen City Sand & Supply Co., Buffalo, N.Y. He will cover western New York, northwestern Pennsylvania and southern Ontario. For the past six years he has been with Worthington Corp., Buffalo, N. Y.

Jefferson J. Davis . . . formerly vice-president in charge of product division at Electric Steel Foundry Co., Portland, Ore., has been named executive vice-president. He has been with Electric Steel Foundry for 24 years, starting as office manager.


J. J. Davis


R. E. Anderson

Ralph E. Anderson . . . is now chief metallurgist, Brillion Iron Works, Inc., Brillion, Wis. He was formerly research metallurgist for Owens-Corning Fiberglas Corp., Newark, Ohio.

P. H. Hookings . . . is now foundry superintendent, Granby Mining Co., Princeton, British Columbia. He was formerly with Major Aluminum Products Ltd., Vancouver, British Columbia.

G. L. Barrett . . . is now superintendent, Alberta Steel Foundries, Ltd., Edmonton, Alberta. He was formerly with Foothills Steel Foundry & Iron Works, Calgary, Alberta.

Paul Schroeder . . . formerly plant superintendent, Kensington Steel Div., Poor & Co., has been named as vice-president of manufacturing of Kensington Steel, Chicago.

Prof. A. L. DeSy . . . University of Ghent/Ghent, Belgium, has been nominated member of the Academy of Science (Royal Flemish Academy of Belgium) and elected honorary member of the Societe Francaise de Metallurgy.

S. C. Massari . . . AFS Technical Director, has been named technical consultant "on call" to the Commanding Officer of Watertown Arsenal, Watertown, Mass.

obituaries

Thomas Beaulac, 68, died Feb. 4 in Glens Falls, N. Y. He entered the foundry line as an apprentice molder and following advancements served as a foundry superintendent for shops in Pennsylvania and Belleville, Ontario, Canada, for 20 years until 1949. He then entered the sales field, first for Dayton Oil Co., and then for Bloomsbury Graphite Co., Bloomsbury, N. J. After retiring in 1957 he moved to Glens Falls. He was active in chapter activities and served as a director of the AFS Northwestern Pennsylvania Chapter.

J. D. Ramsay, former president and director of North American Refractories Co., Cleveland, died suddenly at his home in Shaker Heights, Ohio, Jan. 31. He was the first president of North American Refractories and held the position of top officer and director until his retirement in 1947.

Herbert L. Mausk, 69, retired vice-president of National Malleable & Steel Castings Co., Cleveland, died Feb. 20 at his home in Tryon, N.C. He had served with National Malleable for 50 years and from 1951-1957 was vice-president in charge of sales, transportation and products division.

Frank D. O'Neil, 58, vice-president and treasurer of Western Foundry Co., Div., Consolidated Foundries & Mfg. Corp., died Feb. 6 in Mobile, Ala., where he had been vacationing.

Daniel G. Burkert, 70, a director of Eastern Foundry Co., Boyertown, Pa., died in February. He had been the firm's president prior to his retiring five years ago. Previously he had been associated with Sanitary Co. of America, East Greenville, Pa., and Union Mfg. Co., Boyertown, Pa.

James F. Dorris, Sr., vice-president, Eureka Foundry Co., Chattanooga, Tenn., died Jan. 6.

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make mistakes hard to make! Mistakes cost money–but distinctively shaped Vancoram Briquettes cut errors to the bone. They help assure that the right amount of the right alloy gets into every melt. VCA supplies every major type: FERROSILICON (Cylindrical), FERROMANGANESE (oblong), FERROCHROMIUM (hexagonal), and SILICOMANGANESE (square). Every one sets a standard of excellence! Get Vancoram Briquettes in bulk, bags, or pallet boxes. Call your VCA representative for facts and figures—or any of the VCA Distributors listed below. Vanadium Corporation of America, 420 Lexington Avenue, New York 17, N.Y. Chicago · Cleveland · Detroit · Pittsburgh

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Be sure to visit our Booth (No. 1414) at the AFS Castings Congress, Philadelphia, May 9-13.

VANADIUM
CORPORATION OF AMERICA
Producers of alloys, metals and chemicals

VANCORAM

Circle No. 163, Page 17

foundry trade news

GRAY IRON FOUNDERS' SOCIETY . . . and Designers for Industry, Inc., have announced a cooperative iron casting design service for the metalworking industries in United States and Canada. Designers for Industry, Inc., will serve as specialists in casting design, specifying, cost reduction, research and development and associated technical areas through its special castings department and consultation with G.I.F.S.

STEEL FOUNDERS' SOCIETY . . . reports that member foundries' production in 1959 exceed that of 1958 by 25 per cent in spite of last-half production reductions caused by the steel strike. Steel casting production rebounded 100 per cent from the peak low month of July, 1958 to the peak high month of May, 1959.

General Electric Co. . . . X-Ray Dept., Milwaukee, announces that the sale and service of industrial x-ray equipment will be handled by the G. E. Apparatus Sales Division and the G. E. Industrial Section.

Refractory & Metallurgical Products Co. . . . Detroit, has been formed to manufacture superefractory products for applications in the steel, foundry and metalworking industries. Officers are Raymond W. Morgan, president and treasurer and Warren L. Pell, vice-president and secretary.

H. K. Porter Co. . . . will invest approximately $4,000,000 in new construction and equipment modernization of its Refractories Division plants at Bessemer, Ala., and Wellsville, Ohio. Almost $2,000,000 will be spent at the Bessemer Works for a new factory building and storage facilities, a tunnel kiln, dryers and new brickmaking facilities. At the Wellsville Plant about $1,500,000 is for two new tunnel kilns, additional dryers and new machinery and equipment. An estimated $455,000 will be invested in a new mechanized clay mine.

Pickands Mather & Co. . . . has re-located its pig iron and coke sales office from Washington, D. C. to 30 Rockerfeller Plaza, New York.

Case Institute of Technology . . . Cleveland, has started excavation on a new

Continued on page 142

America's three newest cars, the compact Valiant, Falcon and Corvair, average 73 lb of aluminum each, 17 lb more than the average of all 1960 autos. The Corvair is powered by the first mass-produced aluminum engine in America.

foundry trade news

Continued from page 139

$2,300,000 metallurgy building which will have twice as much space as the present building which is to be torn down. The six-story building will contain approximately 71,450 sq ft and will be completed about Sept., 1961. Plans for the metallurgy building were included in the objectives of the Case $6,500,000 building fund which started in late 1957 and recently topped the $6,000,000 mark. It will provide research laboratory and teaching areas for the investigation of the effect of ultra-high temperatures on materials and for the study of ultra-strength materials as well as facilities for a number of new fields on the Case campus such as ceramics.

Pennsylvania Glass Sand Corp. . . . New York, has moved its southwestern regional sales office from Tulsa, Okla., to 292 Meadows Building, Dallas, Texas.

Kaiser Refractories & Chemicals Div. . . . has announced that the names of three of its sales subsidiaries have been changed to the name of the parent organization. The Mexico Refractories Co. of Ohio with offices in Cleveland and Toledo, will now operate as Kaiser Refractories & Chemicals. A similar change has been made by Mexico Refractories Co. of Texas with offices in Houston and Dallas. In Los Angeles, a similar change will be made by Missouri Refractories Co. Kaiser Refractories has also opened a new sales office at 2901 East 4th Ave., Columbus, Ohio.

Marathon Div., American Can Co. . . . is installing a 100,000 lb-a-day spray dryer and other processing equipment for the production of lignosulfonates from spent sulphite liquor at its Green Bay, Wis., pulp and paper mill. The Green Bay facilities, together with those of the company's completely integrated chemical plant at its Rothschild, Wis., mill, make Marathon one of the largest producers of lignosulfonate powders used in foundry core binders and other industrial applications.

Dow Metal Products Co. . . . Div. Dow Chemical Co., Midland, Mich., is now operating a new die casting plant for light metals on a commercial basis.

Stillman Foundry Co. . . . Grand Rapids, Mich., has been purchased by Donald W. Gaertner, Albion, Mich., who has been connected with Albion and Coldwater, Mich. foundries during the past ten years.

Cooper Alloy Corp. . . . Hillside, N. J., has acquired 15,000 sq ft of plant space in Hillside on a long term lease basis for warehousing and shipping purposes.

Textile Machine Works . . . Reading, Pa., is installing new ovens and porcelainizing equipment for its cast iron cookwear. When in operation, 2500 pieces of finished cookwear will be produced in eight hours. Castings will flow continuously on conveyors through the spraying process and then through the baking or burning cycle to the finishing station.

Westover Corp. . . . Milwaukee, now separated from Nomad Equipment Div., continues in management service work. C.E. Westover, company founder, is now chairman of the board; Jeff A. Westover is president and treasurer; Forrest E. Noggle is vice-president and secretary.

Birdsboro Corp. . . . is the new corporate name for Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., which dates back beyond the American Revolution. The name was adopted to reflect its diversification and expansion program.

Harding Mfg. Co. . . . York, Pa., subsidiary of Harding Co., will spend $300,000 to expand and modernize its foundry facilities. The enlarged foundry will cover approximately 32,000 sq ft.

Fall River Foundry Co., Fall River, Wis., formerly wholly-owned subsidiary of Badger Meter Mfg. Co., Milwaukee, has been purchased by William C. Wright of Milwaukee, and associates. Wright, formerly in charge of manufacturing at Badger Meter and president of Fall River Foundry since 1954, did not disclose purchase price of 43,000-sq ft foundry built in 1954 and enlarged in 1958.

Thirteen of class of 16 graduates of **Max S. Hayes Trade School** patternmaking apprentice classes. Apprentices attended school eight hours a day per week for the first three years and received the same wages as when working on the job for the balance of the week in local pattern shops. This was followed by night attendance for two years, consisting of one 3-1/2 hour session per week for 38 weeks.

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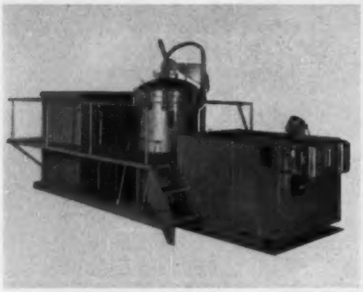
Exhibitors Product Preview

(*Continued from page 50*)

mill and separator and cleaner. Crusher will take oil, synthetic or CO_2-hardened cores or molds.

Vacuum Impregnating Unit Seals Ferrous, Non-Ferrous Castings

High vacuum impregnating unit permanently seals leaks in all types of ferrous and non-ferrous pressure castings. Extremely high vacuum removes all air and moisture from casting and assures penetration of the impregnation material. After this penetration of the seal caused



by the vacuum, air pressure is applied for further seal penetration.

Although the machine is designed for Cast Seal impregnator, excellent results are obtained with such materials as sodium silicate, polyester, vinylite, lacquer, wax, varnish, oil, styrene and phenolic resins. Unit will be displayed by Metallizing Co. of America, Chicago, at the Castings Exposition.

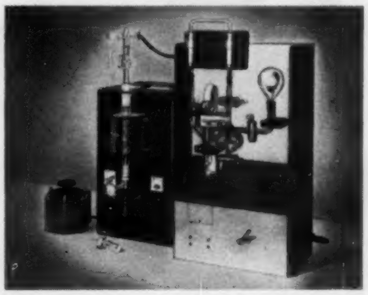
Automatic Permanent Mold Unit Features Speed and Mobility

Automatic permanent mold casting machines, using 8x12 in. or 12x 18 in. mounting plates, speed production through mobility, quick die change feature and automatic timing. Machines are easily moved from furnace to furnace for different alloys. Stahl Speciality Co., Kingsville, Mo., will exhibit machines at the Castings Exposition.

Hydrogen Analyzer Provides Check on In-Coming Materials

New hydrogen analyzer enables the user to check incoming material, control processing, determine the causes of failure and correlate the effects of hydrogen content with physical properties.

The instrument gives rapid hydrogen analysis in such metals as steel and its alloys as well as less refractory, lower melting metals. Extraction time is from three to ten minutes depending upon the material analyzed. Instrument combines speed and accuracy with simplicity of operation. Utilizing the

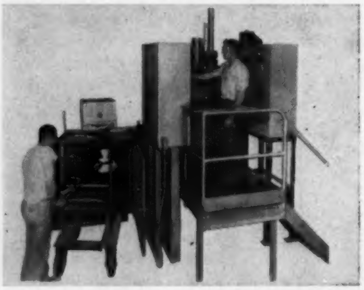


hot extraction principle, the hydrogen analyzer meets the A.S.T.M. requirements (tentative procedure) of 2192 F operating temperature.

Obtain complete details on this unit by visiting the booth of Laboratory Equipment Corp. of St. Joseph, Mich.

Stokes Unit Speeds Vacuum Melting, Casting Operations

Virtually continuous vacuum melting and precision casting operations can be carried on in the versatile new Stokes induction heated vacuum melting furnace. The unit with a capacity of 50-100 lb has a horizontal layout, with the mold chamber (at left in picture) lo-

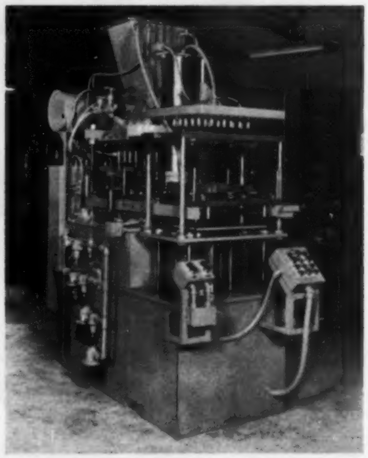


cated alongside and in line with the melting chamber. The two are connected by a "lock" through which the molds are pushed into the melting chamber to receive the pour, and are then withdrawn into the mold chamber, all without breaking vacuum.

Attend the F. J. Stokes Corp. booth at the Castings Exposition for complete details on the first semi-continuous furnaces of standard design to be developed.

Automatic Shell Machine Makes Simultaneous Cores and Molds

A new gas-fired "Blo-Core" automatic shell machine will be exhibited at the Castings Exposition by C&S Products Co. The two-station, rotary shell blower is capable of



producing shell cores and shell molds simultaneously. Available in two sizes, the machine produces up to 100 blows per hour without skilled labor. It can produce horizontally parted boxes up to 16x24x-32 in. draw; vertically split boxes up to 15x24x24 in.

Brown Metals will Feature New Engineering Services

Motif of the exhibit of Brown Metals, Inc., at the Castings Exposition will be their new engineering service for foundries, as well as their line of hot-blast heaters.

Personnel in the booth, to be located at space No. 1210 at the Philadelphia Convention Hall, will

explain the Brown engineering service which includes assistance in plant layout, melting equipment and practice, metal handling, metallurgy and process control. On exhibit will be hot-blast cleaners for supplying preheated air to cupola.

Castings Congress Papers

(*Continued from page 45*)

What is the significance of this study, *Ultra High Pressure Casting*, by J. L. Reiss and E. C. Kron? What melting methods were used? How critical is the time during which pressure is applied? Attend this technical session to learn more about this unusual new technique.

Pressures of 100,000 and 50,000 psi were used. The lower pressure yielded similar properties and was less difficult to use.

Principles of soil mechanics may well be the key that unlocks the door to understanding why green sand molds crack and baked cores hot crack. In *Selected Principles of Soil Mechanics Related to Sand Testing, Molds and Cores*, D. C. Williams reveals a new approach to studying sand flowability.

Use of "impact modulus" for the impact testing of flake graphite cast iron is suggested by the Belgium author, A. DeSy, University of Ghent, who is also chairman of the Working Groups' Panel of the International Committee on methods of testing cast iron.

Says DeSy . . . "We are dealing with a characteristic of the material and not a kind of result depending on the first instance on the particular shape and on dimensions of the test piece. This is indeed the case for the Charpy V-notch or keyhole notch test pieces or any other notched test piece employed for impact tests for steel."

He suggests that the result of the impact test on cast iron should be expressed in terms of energy of rupture per unit volume, called impact modulus.

This technical session, *Gray Cast Iron Impact Test and Impact Modulus*, promises to have international significance in the realm of cast iron testing.

Nonmetallic inclusions, particularly on the cope surfaces of steel castings, variously called snotters or ceroxides, has long plagued foundrymen. Research to identify the defect, find the sources of the inclusions and methods for their elimination has been conducted at the University of Michigan, sponsored by the AFS Training & Research Institute under direction of the Research Committee of the Steel Division. Two progress reports contain the results investigation.

Three sources of nonmetallic macroinclusions in aluminum-killed steel are outlined in part 1.

Two of the reactions are generally known to foundrymen. However, one, the ineraction of aluminum dissolved in liquid steel and ladle refractories, has received less attention. It is covered in part 2, which points out the fallacy that good teapot ladle practice or use of bottom pour ladles will produce a completely clean stream of metal.

A comprehensive report on the causes and possible cures of this universal steel problem will be a feature attraction at one of the technical sessions sponsored by the Steel Division. Part 1 is entitled *Nonmetallic Macroinclusion Causes in Steel Castings Deoxidized with Aluminum*. Part 2 is *Reactions Between Refractories and Molten Steel Containing Aluminum*.

Build an idea file for improvement and profit. Circle numbers on literature request card, page 17, for manufacturers' publications which are yours . . .

for the asking

Core binders . . . composed of group of amino-aldehyde liquid thermosetting resins designed for rapid baking, superior tensile strength and excellent collapsibility. Request technical bulletin. Reichhold Chemicals, Inc.
For Your Copy, Circle No. 60, Page 17

Abrasive performance . . . of steel shot and steelets offered in 18-p brochure. Includes specifications and applications. Wheelabrator Corp.
For Your Copy, Circle No. 61, Page 17

Insulated riser sleeve . . . for non-ferrous castings described in 4-p folder. Johns-Manville Corp.
For Your Copy, Circle No. 62, Page 17

New self-curing sand binder . . . fully described in 8-p technical bulletin. Archer-Daniels-Midland Co.
For Your Copy, Circle No. 63, Page 17

CO_2 process . . . for making molds and cores discussed in booklet authored by reported authority in field of foundry facings. Frederic B. Stevens, Inc.
For Your Copy, Circle No. 64, Page 17

Metal melting . . . and holding furnaces for non-ferrous applications is subject of 12-p brochure. Hevi-Duty Electric Co.
For Your Copy, Circle No. 65, Page 17

Silica sand . . . in 24 grades discussed in folder which pictures various stages in processing. Wedron Silica Co.
For Your Copy, Circle No. 66, Page 17

Industrial fans . . . fundamental data presented in new 28-p bulletin. Lehigh Fan & Blower Div., Fuller Co.
For Your Copy, Circle No. 67, Page 17

Grinding wheel . . . recommendations catalog designed for use by company's salesmen contains over 1600 application recommendations. Carborundum Co.
For Your Copy, Circle No. 68, Page 17

Conveyor units . . . that are adaptable to many situations, shown in 24-p catalog. Includes engineering drawings and data. Logan Co.
For Your Copy, Circle No. 69, Page 17

Controls . . . for foundry furnaces and ovens specified and priced in 40-p booklet. Minneapolis-Honeywell Regulator Co.
For Your Copy, Circle No. 70, Page 17

Chain safety . . . emphasized in six-part kit made up of five folders each dealing with different aspect of chain safety. Also includes 12-p booklet. McKay Co.
For Your Copy, Circle No. 71, Page 17

Gray iron castings . . . specification and purchasing discussed in free reprint. Decatur Casting Co.
For Your Copy, Circle No. 72, Page 17

Platform truck . . . can be used to transport material, tools or personnel. Request bulletin. Prime-Mover Co.
For Your Copy, Circle No. 73, Page 17

Refractories . . . handbook, 130-pp, has been completely revised. Includes new products. Walsh Refractories Corp.
For Your Copy, Circle No. 74, Page 17

Heat processing . . . furnaces for use in stress-relieving aluminum and steel, annealing, heat treating, tempering alloy steel, ageing of castings, galvanizing and nitriding. Despatch Oven Co.
For Your Copy, Circle No. 75, Page 17

Salamanders . . . blower heaters, and infra-red heaters presented in new catalog. No. 259B. Insto-Gas Corp.
For Your Copy, Circle No. 76, Page 17

Grinding wheel chart . . . lists 10 do's and 10 dont's for grinding wheel safety. Grinding Wheel Institute.
For Your Copy, Circle No. 77, Page 17

Copper-base alloys . . . are subject of technical report covering three of these low-shrinkage casting alloys. Brass & Bronze Ingot Institute.
For Your Copy, Circle No. 78, Page 17

Pattern cost reduction . . . is goal of this bulletin. Technique described reportedly is duplicating process eliminating double shrink patterns. Tooling Div., Houghton Laboratories, Inc.
For Your Copy, Circle No. 79, Page 17

Eliminate porosity . . . in castings with lithium copper cartridges, according to company publication, Vol 30, No. 1. Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc.
For Your Copy, Circle No. 80, Page 17

Stress-rupture properties . . . doubled for WI-52 Alloy, a cobalt-tungsten alloy. To find out how this claim was brought about, circle the number below on the Literature Request Card. WalMet Alloys Co.
For Your Copy, Circle No. 81, Page 17

Metal removal . . . company publication is something new. To register for this quarterly house organ, use the Literature Request Card. Arcair Co.
For Your Copy, Circle No. 82, Page 17

Table rooms . . . for blast cleaning of castings described in new 12-p bulletin. Cleans castings up to 10 ft wide weighing as much as six tons. Pangborn Corp.
For Your Copy, Circle No. 83, Page 17

Technical films . . . catalog features films about new products, advanced industrial processes and new techniques. All films free loan. Modern Talking Picture Service, Inc.
For Your Copy, Circle No. 84, Page 17

Wall chart . . . shows gaseous equivalents of liquid oxygen, nitrogen and argon. Ronan & Kunzl, Inc.
For Your Copy, Circle No. 85, Page 17

Pyrometers . . . detailed in catalog No. 175. Includes optical, micro-optical, radiation, immersion, surface and indicating types. Pyrometer Instrument Co.
For Your Copy, Circle No. 86, Page 17

X-Ray . . . spectrochemical analysis in industry is subject of free reprint covering detailed applications, scientific theory, instruments, and specification data. Applied Research Laboratories, Inc.
For Your Copy, Circle No. 87, Page 17

Equipment leasing . . . pros and cons outlined in brochure. Foundation for Management Research.
For Your Copy, Circle No. 88, Page 17

Management . . . reportedly can save unlimited time with instrument panel system designed to monitor project progress; scores of different applications. Photographic reproduction of panel serves as report. Wassell Organization, Westport, Conn.
For Your Copy, Circle No. 89, Page 17

Anodizing . . . of aluminum discussed in new booklet. Reynolds Metals Co.
For Your Copy, Circle No. 99, Page 17

Colloidal dispersions . . . also semi-colloidal, for lubricants, discussed in case history reports. Includes reported better surface finish in permanent mold coating, and labor saving report. Jaqua Co.
For Your Copy, Circle No. 100, Page 17

Drafting equipment . . . and supply catalog, 100 pp, features all equipment and supplies for modern drafting work. Alfred Mossner Co.
For Your Copy, Circle No. 101, Page 17

Furnace master station . . . shown and described in data sheet. TOCCO Div., Ohio Crankshaft Co.
For Your Copy, Circle No. 102, Page 17

Industrial gases . . . and how they may be put to use in your plant is subject of brochure. Linde Industrial Gases.
For Your Copy, Circle No. 103, Page 17

Crucible melting . . . problems are basis for short articles written to help solve melting problems for association members. Individual sheets have been com-

bined into pamphlet form, which is yours for the asking. Crucible Manufacturers Association.
For Your Copy, Circle No. 104, Page 17

Removes tramp iron . . . all of it, according to manufacturer. Electromagnetic pulley, claimed to do the job even on fast conveyors, completely detailed in bulletin. Stearns Magnetic Products Div., Indiana Steel Products Co.
For Your Copy, Circle No. 105, Page 17

High alloy steel . . . castings are produced in this foundry. Facilities and products shown in step by step procedure in fully illustrated brochure. St. Louis Steel Casting Inc.
For Your Copy, Circle No. 106, Page 17

Cobalt . . . publications of the Cobalt Information Center are available to you for the asking. A few of them follow.
For Your Copy, Circle No. 107, Page 17

Use of Cobalt in Stainless Steel
For Your Copy, Circle No. 108, Page 17

Cobalt in Cast Iron
For Your Copy, Circle No. 109, Page 17

The Uses of Cobalt
For Your Copy, Circle No. 110, Page 17

Alloys for the Aircraft Industry . . . The Role of Cobalt.
For Your Copy, Circle No. 111, Page 17

Machining . . . of cobalt-containing alloys covered in new technical instruction report including data on selection of drill size, alloy condition, tool material, feed speed, cutting fluid, etc. Cobalt Information Center.
For Your Copy, Circle No. 112, Page 17

Ceramic fiber . . . said to withstand operating temperatures to 2300 F. Typical uses discussed in 8-p brochure. Carborundum Co.
For Your Copy, Circle No. 113, Page 17

Air cylinders . . . rated for up to 750 psi operation and related products shown in new bulletin, 24pp. Flick-Reedy Corp.
For Your Copy, Circle No. 114, Page 17

Industrial scales . . . include models for wide variety of industrial applications. Request brochure. Toledo Scale Corp.
For Your Copy, Circle No. 115, Page 17

Motor-generator chargers . . . automatically controlled, covered in 8-p bulletin containing electric industrial truck and other motive power applications. Exide Industrial Div., Electric Storage Battery Co.
For Your Copy, Circle No. 116, Page 17

Induction heating . . . equipment completely described in 8-p bulletin covering billet heating, heat treating, joining, melting and sintering. Ajax Magnethermic Corp.
For Your Copy, Circle No. 117, Page 17

Analytical services . . . and quality control for industry and government offered through laboratories shown in the pages of this brochure. Spectrochemical Laboratories, Inc.
For Your Copy, Circle No. 118, Page 17

Vacuum spectrometer . . . is subject of paper prepared by a Pittsburg steel manufacturer. Unit reportedly will pay for itself in less than six months, according to the paper, which is yours for the asking. Applied Research Laboratories, Inc.
For Your Copy, Circle No. 119, Page 17

Temperature indicating . . . crayons melt at prescribed temperatures; brochure lists 80 different temperature ratings. Tempil Corp.
For Your Copy, Circle No. 120, Page 17

Metal removing . . . by etching or chemical milling covered in brochure. Process protects areas of castings where removal of metal is not desired. Eastman Kodak Co.
For Your Copy, Circle No. 121, Page 17

Rubber-bonded . . . abrasives specified in folder; includes applications. Carborundum Co.
For Your Copy, Circle No. 122, Page 17

Arc welding electrodes . . . pocket guide, 64 pp, contains complete information on all types of electrodes available from this company. Air Reduction Sales Co.
For Your Copy, Circle No. 123, Page 17

Torque calculator . . . for determining proper flexible shafting power drive cores. Rugged cardboard construction, designed to fit into pocket. Stow Mfg. Co.
For Your Copy, Circle No. 124, Page 17

Sand preparation . . . machinery manufactured by this company reportedly offers a complete line for every foundry from the smallest to the largest. Units shown and described in Bulletin 1230. Beardsley & Piper Div., Pettibone Mulliken Corp.
For Your Copy, Circle No. 125, Page 17

Combustion system . . . for gas-fired, infrared heat treating furnaces employs new luminous wall process. Technical bulletin No. 209, 48 pp, discusses research, how process works, and applications. Holden Metallurgical Products.
For Your Copy, Circle No. 126, Page 17

Dust and fume . . . control system catalog features 60 plant installations, 52 pp. Kirk & Blum Mfg. Co.
For Your Copy, Circle No. 127, Page 17

Tool manual . . . pocket booklet designed as aid to selection, application and maintenance of cemented carbide cutting tools; 64 pp. Kennametal Inc.
For Your Copy, Circle No. 128, Page 17

Remote weight recording . . . units feature transmitting and recording of weights on adding machines, typewriters, tape punch or card punch units or indicated in illuminated numerical form. Request Form 2975a. Toledo Scale Corp.
For Your Copy, Circle No. 129, Page 17

Investment castings . . . booklet includes seven case histories said to show how investment castings give product improvement with cost reduction. Engineered Precision Casting Co.
For Your Copy, Circle No. 130, Page 17

Cleaning barrels . . . exclusive features described in 16-p bulletin No. 706. Designed for manufacturers of small-to-medium-size castings. Pangborn Corp.
For Your Copy, Circle No. 131, Page 17

Power tool . . . catalog includes new models being introduced this year. Sixty-page catalog is yours for the asking. Boice-Crane Co.
For Your Copy, Circle No. 132, Page 17

Sand binder . . . bulletin covering use of binder said to offer greater flowability, compactability and permeability. Dow Chemical Co.
For Your Copy, Circle No. 133, Page 17

High-speed conveying . . . of bulk materials which are hurled into areas inaccessible by other means. Read about this unit in new 6-p folder. Link-Belt Co.
For Your Copy, Circle No. 134, Page 17

Pig iron . . . available in three sizes discussed and specified in 6-p folder. Keokuk Electro-Metals Co.
For Your Copy, Circle No. 142, Page 17

Free reprints

■ **The following reprints of feature articles which appeared in MODERN CASTINGS are available to you free of charge. Use the Literature Request Card.**

Induction melting . . . process fabricates 60,000-lb stainless steel paper mill rolls. Read about it in free reprint from MODERN CASTINGS. American Foundrymen's Society.
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Lanthanum . . . and its use to soften ductile iron castings is subject of free MODERN CASTINGS reprint. American Foundrymen's Society.
For Your Copy, Circle No. 136, Page 17

Corn sugar binder . . . reduces baking time and improves casting quality in steel foundry coremaking operation. Free MODERN CASTINGS reprint. American Foundrymen's Society.
For Your Copy, Circle No. 137, Page 17

Titanium castings . . . marketing problems and outlook for the future covered in MODERN CASTINGS reprint. American Foundrymen's Society.
For Your Copy, Circle No. 138, Page 17

Mechanized molding line . . . producing 240 molds per hour with five employees is subject of reprint from MODERN CASTINGS. American Foundrymen's Society.
For Your Copy, Circle No. 139, Page 17

Brass fumes trapped . . . with portable collector described in MODERN CASTINGS reprint. American Foundrymen's Society.
For Your Copy, Circle No. 140, Page 17

Carbon refractories . . . in cupola construction resist slag attack, have high strength at elevated temperatures. MODERN CASTINGS reprint. American Foundrymen's Society.
For Your Copy, Circle No. 141, Page 17

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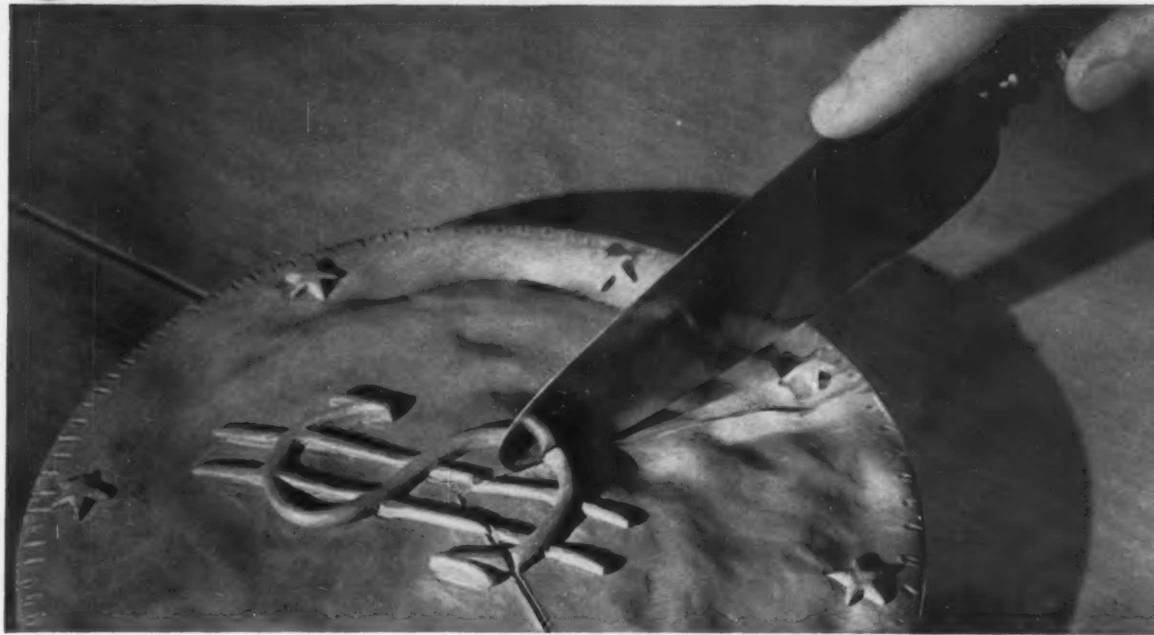

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Circle No. 170, Page 17

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Circle No. 172, Page 17

Abstracts of International Foundry Congress Papers

Complete copies of these papers have been placed in the Library of the American Foundrymen's Society. After reading the abstracts, you may want complete copies for your file. Copies of the original paper, in the language of presentation, are available at 20 cents per page. The language and length of papers are given at the end of each abstract. Address orders to Book Dept., AFS, Golf & Wolf Rds., Des Plaines, Ill.

MODERN CASTINGS presents here the last in a series of abstracts of technical papers presented at the 26th International Foundry Congress in Madrid, Spain

Melting and Strickles Molding of Spiral Chambers for Hydraulic Turbines by Victor Gomez Oliva.

A molding process is described for which it is claimed that a cost reduction and improvement of size, shape and finish of casting is obtained. This is made possible by improving the molding equipment usually employed in foundries. . . . 5 pages in Spanish.

A New Molding Sand Control-Factor, The pH by Juan Castells Ruiz.

This paper is intended to determine the cause of a surface defect which appears in certain cases on gray iron castings and steel castings, when molding sand is intensively used after a long shutdown.

A control method consists in measuring the acidity or basicity (alkalinity) of the sand mixture.

Raising pH by adding alkaline products to the return sand gives entirely satisfactory results.

This remedy proved to be the solution to this scab defect. . . . 12 pages in Spanish.

The Control of the Graphitization in the Gray Iron Castings by Jose-Oriol Cadellans Oller.

Some examples of the application of the chill test are presented for the control of graphitization at a foundry which has specialized in high strength alloys, with and without alloy elements. From the results obtained through the chill test we conclude that it allows us to control with surety and rapidity the aptitude of the cast metal for graphitization. . . . 9 pages in Spanish.

Quality Control in Casting Process by Ernesto Ruiz Pala.

Use of quality control charts for variables during casting process is of high utility to guarantee uniformity and quality level. Mold properties depend on its permeability, consistency and moisture content. Drawing correlation curves between sand properties and mold hardness for each moisture content, it is possible to control work watching the latter, as well as to establish convenient limits in function of minimums allowable for permeability and consistency. . . . 5 pages in Spanish.

The Influence of Sulphur in High Quality Gray Iron Strength and Hardness by Jeronimo Vazquez White.

The principal object of this work has been to corroborate the influence that sulphur has on the mechanical characteristics of gray cast iron especially when the amounts of sulphur are very low.

The following conclusions have been reached.

1) All the S contained in the casting is in the form of SMn.
2) Although it is possible to neutralize

Continued on page 152

International papers

Continued from page 163

all the S with Mn, it is convenient to establish an upper limit.

3) In certain cases it is necessary to establish a low limit to the contained S. An unlimited desulphurization is not advisable.

Charts have been made with values thus obtained and the following conclusions have been reached.

"In high quality gray cast iron the content of S must be maintained between 0.095 per cent and 0.180 per cent in order to get on the one hand the required mechanical characteristics and, on the other, to avoid the presence of hard zones. . . . 7 pages in Spanish.

Recommendation on the L-214 Alloy Casting and Treatment by Jose Aguilera Cullell.

The experience obtained with 1082 test bars has permitted to establishing several recommendations in order to avoid unusual conditions which have been possible to prevent in the later castings. . . . 8 pages in Spanish.

Bainitic Cast Iron to the Cu-Mo-Cr by Mario Pujol Roig.

Bainitic cast irons are studied here in terms of mechanical characteristics and micrographic components.

The optimum mechanical characteristics have been obtained with a tempering at 400 C. When normalized the hardnesses obtained are high but the tensile strength drops.

The micrographic components have been studied in all states and the tensile strength drop has been explained as a result of the treatment. . . . 12 pages in Spanish.

Some Observations on the Variation of Modulus of Elasticity in Cast Iron by Max Russenberger.

The stability of a cast iron-steel construction depends on rigidity. Rigidity depends on the modulus of elasticity of the material used. If the modulus of elasticity is constant, the repeated application of the same load will produce an always identical flexure. If, on the other hand, the modulus of elasticity is influenced by a stress previously undergone, it may happen that the repeated application of an identical load will not give the same flexure. So the accuracy of a machine-tool which has been designed on the basis of a material with a non-reversing property is easily estimated. . . . 2 pages in Spanish.

Specification of the Nodular Cast Iron by Thickness by Arturo Arasti Abaunza.

We can summarize the obtained results as follows:

a) The inoculation of molten iron with mischmetal presents a saving of 40 to 50 per cent of Fe Si Mg alloy. The result is a shorter cooling and you don't need to use pig-irons of great purity.

b) Greater percentages of alloy can be used at the same time the casting thickness increases because excessive quantity of alloy increases the quantity. of carbides.

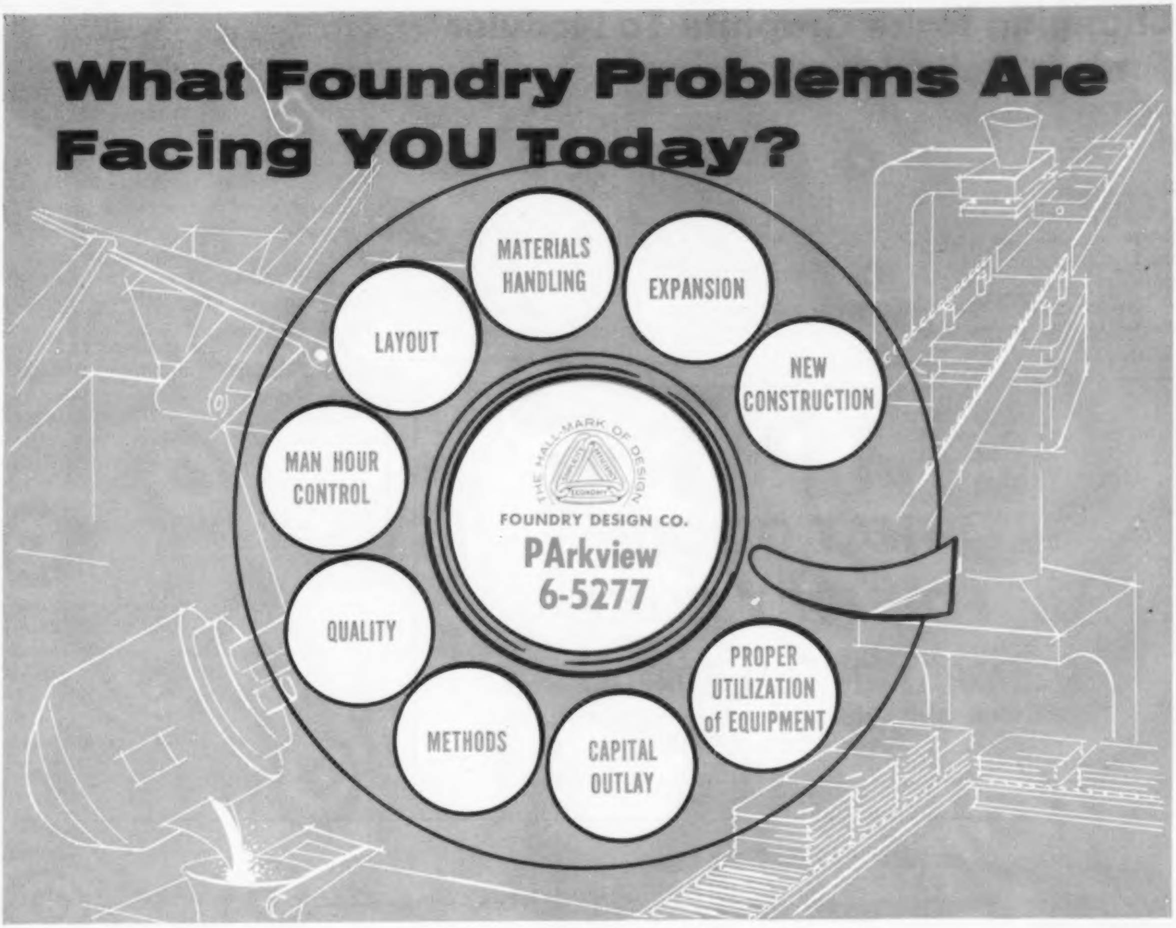
In order to obtain good mechanical characteristics, it is only necessary that the nodular percentage exceeds 40 per cent of the mass of graphite. The pearlitic matrix becomes coarser in accordance with the increasing of the thickness. . . . 13 pages in Spanish.

Contribution to the Study of the Factors That Improve the Elasticity Modulus of the Cast Iron by Alberto Sole Amat.

In this paper the author emphasizes the importance of knowing the elastic modulus of a cast iron as it is a true criterion for estimating the quality of the material. Several tappings have been made to observe the influence of the cooling velocity, the composition, the addition of inoculatives and other possible elements. In each tap and in each section the elastic modulus, the hardness, tensile strength, degree of eutectic saturation and chemical composition have been determined.

Segregations of the Eutectoid "Alpha-Delta" in the Cu-Sn by Francisco Joanxich Ayma.

In this paper a few examples are studied about the massive formation of the eutectoid "alpha-delta" in Cu-Sn alloys cast in sand molds. . . . 13 pages in Spanish.



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Circle No. 188, Page 17

Changing Flake Graphite To Nodular Form In Solid State

Translated from Liteinoe Proizvodstvo, Sept. 1959

■ In recent years papers have appeared hinting at the possibility of producing nodular cast iron by a treatment of cast irons in the solid state.

Investigations of the change in the shape of the graphite during diffusion treatment of cast iron in the solid state with lithium have been carried out using the procedure developed by F. N. Tavadze, E. S. Kartoziya and M. A. Essen (employed for the diffusion treatment of iron-carbon alloys with magnesium). Cast iron specimens and lithium were placed into closed steel containers with joints welded for maximum air tightness. The containers were placed into a furnace, heated to 2010 F, held for 15 hours and furnace cooled.

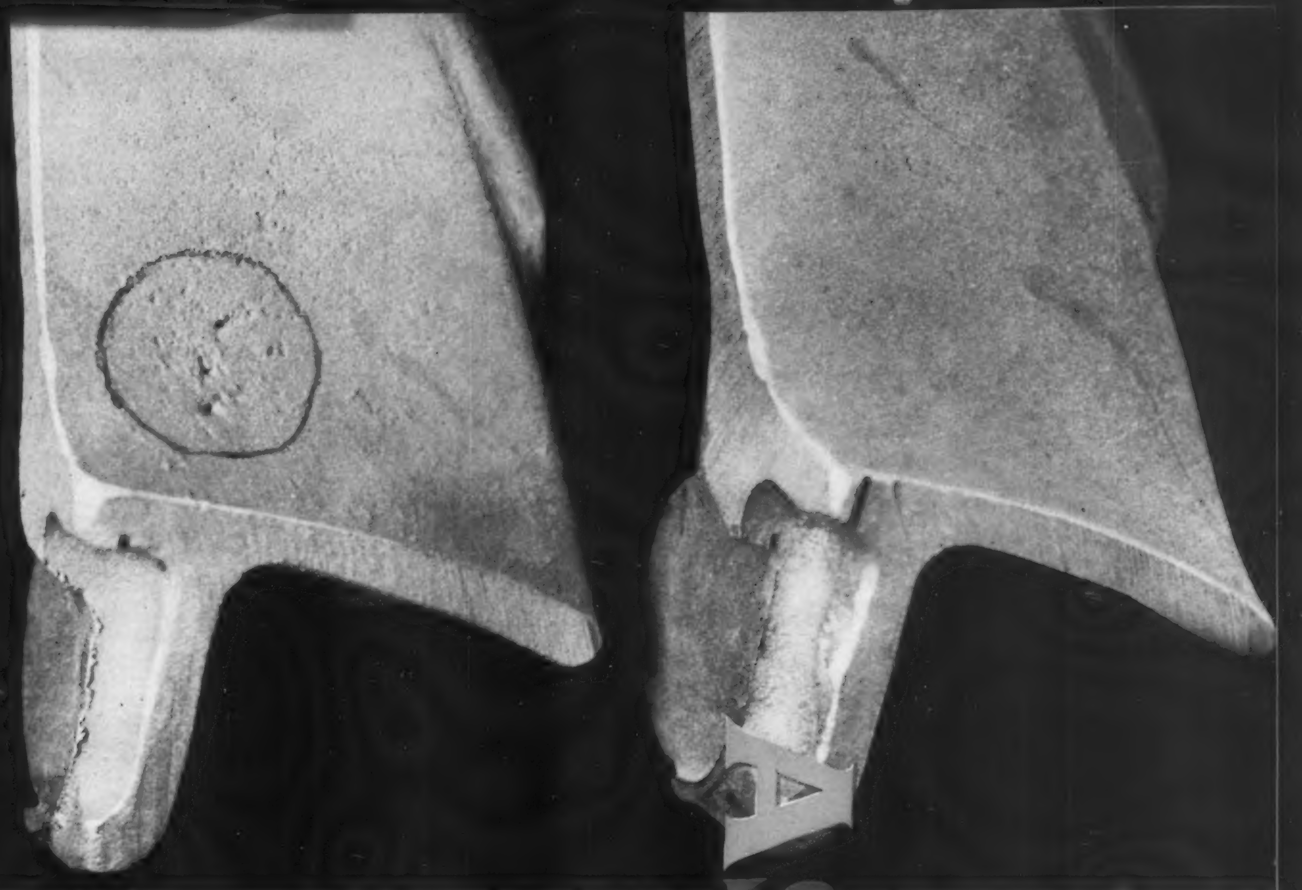
Cast irons of different chemical composition were used in the investigation. All cast irons were first annealed until a ferritic-flake graphite structure developed. A metallographic examination of the cast irons after the diffusion treatment established the change in the shape of the graphite to a nodular form as a result of the treatment, irrespective of its initial shape.

It was thus demonstrated that the shape of the graphite could be changed from flake to nodule by treating cast iron in the solid state with lithium.

Silicon content has an effect on the change in the shape of the graphite but increased sulphur content does not prevent its change into spherules.

The change in the shape of the graphite can evidently be linked with the diffusion of the lithium into the cast iron. The action is analogous to the results obtained from diffusion treatment of cast iron in the solid state with magnesium.

■ Condensed from a translation by H. Brutcher; circle No. 228, page 17, for a list of Brutcher Translations available for purchase.



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Circle No. 176, Page 17

Have you read?

Nondestructive Testing Handbook . . . The Society for Nondestructive Testing. Ronald Press Co., New York. 1959. Two volumes cover the principles and background of 24 various testing methods, test applications, procedures and interpretation. These volumes will be practical handbooks for research and engineering groups, manufacturing and processing personnel, as well as those working in industrial maintenance fields.

Air Pollution Control . . . W. L. Faith. 259 pp. John Wiley & Sons, Inc., 440 4th Ave., New York. 1959. This book tracks down the nature and source of the more common air pollutants and discusses appropriate means of controlling emission at the source. The newer aspects of air pollution, particularly the automobile exhaust problem and the hazard of radioactivity, as well as the legal complexities of this controversial question are described.

Exploring Patternmaking and Foundry . . . Harvey D. Miner and John G. Miller. 206 pp. D. Van Nostrand Co., 257 Fourth Ave., New York. 1959. The text is written specifically for beginners in the patternmaking and foundry trades. Suited to use in trade or vocational schools. More than one hundred line drawings and photographs illustrate the equipment and techniques for making patterns and equipment.

Accident Prevention Manual for Industrial Operations, 4th Edition . . . 1542 pp. National Safety Council, 425 N. Michigan Ave., Chicago. 1959. A "summation of 46 years of safety experience," the manual was compiled, edited and reviewed by safety specialists. It draws on the knowledge of safety men from nearly 7000 firms spanning every U. S. industry. The publication contains more than 500 illustrations and 1542 pages of up-to-the-minute data on every aspect of industrial safety.

A.S.T.E. Collected Papers, Book II, vol. 59 . . . American Society of Tool Engineers, 10700 Puritan Ave., Detroit. 1959. Book II contains all the technical papers given at the Society's semiannual meeting in St. Louis in October. Included in the bound Library edition are articles on product engineering, fabricating processes, manufacturing planning and control, tooling design, metalworking principles, metal forming, engineering materials, quality control, manufacturing management and four papers of general interest.

Circle No. 181, Page 17

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by H. A. Williams
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- A thorough understanding of our gaging practices, using in their operations identical or similar gages to ours.
- An alert, preventive maintenance program to adequately protect our investment in patterns and to prevent our being burdened with undue repair or replacement costs.
- A scheduling program consistent with our needs—sufficiently flexible to meet the production peaks and valleys that, through experience, we know are inherent to our industry.

This article contains highlights abstracted from a paper presented at the 1959 Missouri Valley Regional Foundry Conference.

dietrich's corner

by h. f. dietrich

The Practical Joker

■ We know that for safety's sake horseplay cannot be tolerated in the foundry. However, try as we will we cannot eliminate entirely the so called practical joke. Although the original joke could be embarrassing, or even slightly painful, it is the secondary reaction that is fraught with danger.

The pranks played in the foundry are as old as the industry itself. Any molder who has filled a flask from a sand heap knows the nerve shocking sensation of driving his shovel into a buried mold-weight or pig. Seldom is the weight buried at the end of the shovel stroke where it will only slightly effect the molder's arm.

The shock of a shovel hitting metal can be heard for a distance of six floors on either side of the victim. This allows the audience to howl with glee while the victim's hand and arm go numb and his shoulder feels as if it had been pulled from its socket. If the victim will utter a stream of profanity while he grasps his broken hand, the thrill of enjoyment will be even greater for the jokester's public.

The greased handle gimmick is as old as grease and handles. Only once have I seen this script develop into an unusual ending.

A gangwayman on our shift had been the butt of this trite joke so often that he had lost all appreciation of the humor in it. He felt it was time he called someone's attention to the inhuman treatment he had been receiving.

Setting his wheelbarrow in the gangway where he knew the inevitable would happen, he retired to the restroom. Upon his return he stood beside the baited vehicle until the Superintendent wandered up the gangway. When the Super drew alongside, the sand buggy jockey suggested that the Super test the weight and balance of the prehistoric device.

In the hiarchy of this foundry the Super was protected from the humor of the pranksters. No practical joker who had developed a habit of eating would satisfy his sense of humor by making the Super play straightman. Without giving it a second thought, the Super stooped and grasped the handles. Gobs of grease oozed between the fingers of both hands.

The Super had perfect control of a violent temper. Rising slowly, he stood gazing at the gangwayman while a crimson wave of color rose from his throat to the roots of his closely cropped light blonde hair. His lips turned an ashen white and his chin began to quiver while he took the handful of waste preoffered by the mute former gangwayman. Slowly, he removed the greater part of the grease from his hands.

Softly and through clenched teeth he said, "You will get your check in the office."

Another gag that's good for an illiterate laugh or two—and a ruptured vertebra disc—is to fill a large coke wheelbarrow with pig covered and hidden by coke. More than one back has been permanently bent by this hilarious prank. A rod wired to the wheel in such a manner that the wheel will make almost a complete turn before coming to an abrupt stop will result in a lot of fun for some people—and a broken rib or two.

I suggested in the beginning of this article that the secondary reaction is often more dangerous than the prank.

The court jester usually selects his victim with great care. It is the person least able to defend himself who becomes the butt of his cowardly humor. He doesn't appreciate the humor of a joke that misfires. He will do his best to make up the loss and regain his public. Being stupid or ignorant of the danger involved, he will use fire, water, air or electricity to maim his uncooperative victim. Anything for a laugh.

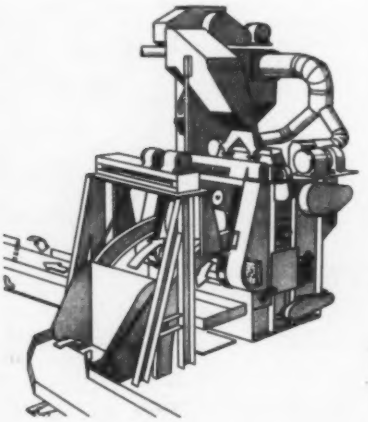
Try as we will we can never entirely eliminate the energetic mayhem and infantile brutality of that life of the party, The Practical Joker.

product report . . .

Labor costs on cleaning operations have been cut one-third at the Canadian Westinghouse Corp. plant at Hamilton, Ont., Canada, through use of automation and a 27-cu ft Pangborn blast cleaning barrel.

The 27-cu ft unit replaces two 18-cu ft capacity batch type cleaning barrels, each of which required a full time operator plus a third operator to run one of the barrels on the second shift. Now second shift cleaning has been eliminated and two of the three men formerly on cleaning are now freed for other foundry work.

Full automation has not been realized but installation of additional conveying equipment will mechanize the entire cleaning operation with additional savings.



Results to date include reduction of manhours from 24 to eight, cutting of cleaning time per load from 20 min to eight, elimination of crane handling time, speeding up of shakeout operations with the substitution of an oscillating conveyor and a saving of $11,000 yearly on maintenance costs.

The new barrel is completely lined with wear-resistant plates which have logged more than 1200 hours of blast time with no signs of wear. Formerly, steel wear plates lasted a maximum of 200 hr.

Foundry production is 800,000 lb of castings per month with 70 per cent going through the new barrel in loads of 2000-3000 lb, ranging in size up to air brake reservoirs two ft square.

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pouring off the heat

foundry survival

■ I read with very much interest and complete agreement the article entitled "Your Foundry Cannot Survive Unless" which was published in the December issue of Modern Castings.

All forward-thinking foundrymen realize that we must continue to upgrade our products if we are to hold and expand our position as one of the basic suppliers of parts for tomorrow's machinery and equipment.

This can be accomplished only by better trained and better qualified personnel—administrators, technicians and operators—in the foundry industry.

This ambition for immediate, as well as future, improvement in the leadership of our industry is apparent in all sized shops. Ranging from cooperative student employment, scholarships, enrollment in extension courses and American Foundrymen's Society technical courses to well organized in-shop training schedules, each company is attempting to find its individual answer.

One can't fail to be impressed by the sincere efforts being made. Whether these efforts, however sincere, are adequate and broad enough to attain the desired results and achieve our long range goals, only time can determine.

I don't think anyone is completely satisfied with his own program or progress. The remarks of Messrs. Simpson, Culling and Woehlke are calculated to stimulate a review of objectives with overall improvement in mind. Their ideas are constructive, timely and sound and they deserve our thanks for outlining so well the major problem of our industry.

R. S. Bradshaw, Jr.,
President and General Manager
Texas Foundries, Inc.
Lufkin, Texas

■ Modern Castings is to be congratulated on the article in the December issue entitled, "Your Foundry Cannot Survive Unless."

Most of the papers in your excellent publication necessarily pertain to technical areas and unfortunately management's efforts are proportionately in the same direction.

Foundrys must develop operating supervision, technical personnel and administrative management. But are these areas receiving the proper attention? An article of this nature prompts one to re-evaluate the situation.

Present-day customer demands clearly indicate the need for foundrys to create or to expand existing facilities and personnel in the areas of metallurgy, quality control, cost reduction, research and development, etc . . . not only to better control and improve their own techniques but also to assist the customer in casting problems which develop in their constant effort toward product improvement.

Success for all concerned hinges on co-ordination of the technical phase and the art phase. Only long experience in the production of quality castings can bring this about.

Joseph B. Essex, *Vice-Pres. Mfg.*
Golden Foundry Co.
Columbus, Ind.

international classification

■ The article by Dr. Adalbert Wittmoser entitled "International Classification of Ferrous Cast Metals" published in the December issue of Modern Castings, is very interesting. I agree with him that there has been some misunderstanding in the past in the evaluation of many cast ferrous materials. His article has gone a long way in clearing up some of the misinterpretations prevalent in the minds of designers and manufacturers.

I am sure that not everybody will agree one hundred per cent on the classification as discussed by Dr. Wittmoser, but his basic classification meets my approval.

Carl F. Joseph, *Technical Director*
Central Foundry Div., GMC
Saginaw, Mich.

■ Dr. Wittmoser's proposed system for International Classification of Ferrous Cast Metals is quite interesting, indeed. I had an opportunity to discuss part of this plan with representatives of the cast metals industry in Germany when I was over there last August. You should be commended for bringing such a thought-provoking discussion to the attention of your readers.

Unfortunately, one error crept into the translation: There is no such thing as malleable cast iron. Our industry is still suffering severely because its product is being lumped in with cast iron. The German term "Temperguss" should be translated "malleable iron" not "malleable cast iron." I am sorry that this happened.

Hans J. Heine, *Technical Director*
Malleable Founders Society
Cleveland

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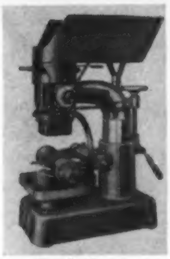

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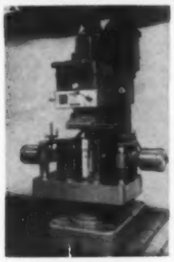

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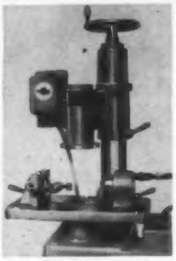

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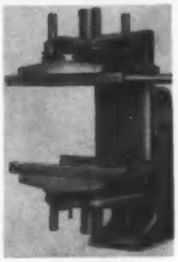

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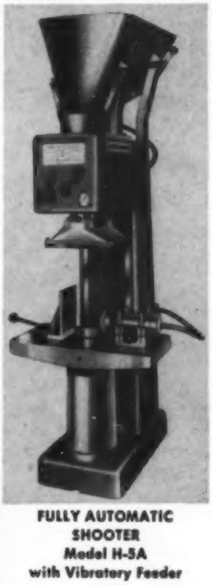

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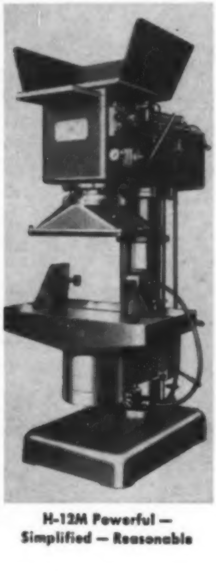

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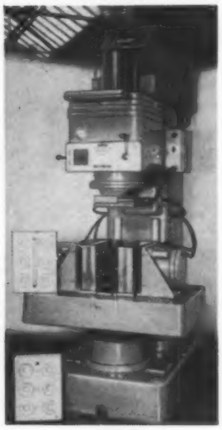

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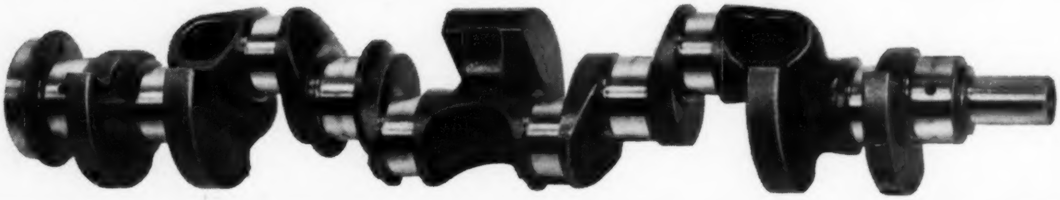
FORD'S FALCON CRANKSHAFT...



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- castings have closer tolerance, require less machining
- shell molds are portable and use less sand
- in fact, foundry efficiency, flexibility and production rate are increased

And RCI FOUNDREZ resins are ideal for shell mold applications because:

- RCI is a basic producer of both phenol and formaldehyde, which guarantees quality control from raw material to finished product.
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